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Applicant:	Eric Yves Therlault et al.	Examiner:	N/A
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COMMUNICATION REGARDING PRIORITY DOCUMENT

Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Please place the following Certified Priority Document into the file of the above-identified patent application, as follows:

United Kingdom, Patent Application No. 0109750.0, filed April 20, 2001

Respectfully submitted,

Eric Yves Theriault et al.

By their attorneys,

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INVESTOR IN PEOPLE

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Request for grant of a patent
Grant

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1.	Your reference	2034-P561-GB
2.	Patent application number	20 APR 2001 0109750.0
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	DISCREET LOGIC INC 10 Duke Street Montreal, Quebec Canada H3C 2L7
	Patents ADP number *(if you know it)*	7747572001
	If the applicant is a corporate body, give the country/state of its incorporation	Quebec, Canada
4.	Title of the invention	Image Processing
5.	Name of your agent	ATKINSON BURRINGTON
	"Address for service" in the United Kingdom to which all correspondence should be sent	25-29 President Buildings President Way Sheffield S4 7UR GB
	Telephone No:	0114 275 2400
	Patents ADP number	7807043001

		Country	Priority application number *(if you know it)*	Date of filing *(day/month/year)*
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	N/A	N/A	N/A

		Number of earlier application	Date of filing (day/month/year)
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	N/A	N/A

8.	Is a statement of inventorship and of right to grant of a patent required in support of this request?	Yes

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	33
Claim(s)	05
Abstract	01
Drawings	25 +25

10. If you are also filing any of the following, state how many against each item.

Priority documents	N/A
Translations of priority documents	N/A
Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)	None
Request for preliminary examination and search (*Patents Form 9/77*)	One
Request for substantive examination (*Patents Form 10/77*)	None
Any other documents (*Please specify*)	

11. I/We request the grant of a patent on the basis of this application.

Signature

Date **Thursday, 19 April 2001**

12. Name and daytime telephone number of person to contact in the United Kingdom

RALPH ATKINSON CPA
0114 275 2400

LA-04-070

Image Processing

Field of the Invention

The present invention relates to a network system for image data processing systems, in which a network configuration file on each computer is automatically updated whenever changes are made to the network.

Background of the Invention

Networks for image data processing systems are known that use standard distribution protocols, such as Ethernet, TCP/IP and HiPPI. In video facilities houses, a recent trend has been towards having a plurality of different image processing stations therefore it has been appreciated that highly powered stations, having relatively high hourly charges, may be used for specific operations where a high degree of processing power is required. However, overall charges may be reduced by performing less demanding tasks at more modest stations. Matching the level of the task to the level of the station rather than to the location at which the image data needs to be stored requires methods for transferring that data as quickly as possible.

Co-pending British patent application 00 08 318.8, 2034-P565-GB and 2034-P564-GB describe methods of using a high bandwidth fibre channel switch, connected to a plurality of image processing stations and a plurality of redundant arrays of inexpensive disks (RAIDs), to convey image data over a high bandwidth channel without the cost of setting up a high bandwidth network. This is achieved either by requesting access to data stored in a RAID controlled by another station or by actually taking control of a RAID currently controlled by another station.

In this situation it is necessary that at all times every image processing station within the network is aware of exactly which stations are online and which RAIDs they are connected to, so that if a particular image processing station needs data from a particular RAID it has up-to-date information about which station presently controls that RAID and whether the data is currently available.

It is known to include within a processor a configuration file which contains information about the way in which the network is set up and which connections have been made, but at present these configuration files must be manually updated by a user when a change to the network takes place. It is also known for a computer coming online within a network to announce itself to all connected machines but still the configuration file must be updated manually.

This updating process often necessitates closing down all currently running applications, which is inconvenient and not always immediately possible, and so the configuration file on a particular processing system may remain incorrect for a period of time. Also, manual updating of a configuration file inevitably results in mistakes, especially when the user is unfamiliar or uncomfortable with the technology. Thus a system administrator must often be employed to be in charge of this updating.

Alternatively, one machine within the network could keep a network configuration updated and send it to other machines on request. However, when machines are connected various different networks, each using a different protocol, as is often the case, every machine within a network could require different information. In addition, a system administrator would again be necessary.

Brief Summary of the Invention

Image data processing apparatus, comprising a plurality of image processing systems in which each of said image processing systems has direct access to a respective frame storage means; and a network connecting said image processing systems together so as to allow each connected image processing system to indirectly access the frame storage means of the other connected image processing systems; wherein each image processing system includes a local configuration file specifying details of its respective locally connected storage means, a network configuration data structure, and network communication means; wherein said network communication means is arranged to transmit details of its associated configuration file to other networked image systems, and to add configuration data to its associated network configuration data structure in response to configuration details received from other networked image processing systems.

Brief Description of the Several Views of the Drawings

Figure 1 shows an networked image data processing environment;

Figure 2 illustrates an image processing system of the type shown in *Figure 1*;

Figure 3 illustrates a processor of the type shown in *Figure 2*;

Figure 4 illustrates image frames of the type processed by the system shown in *Figure 1*;

Figure 5 illustrates a redundant array of inexpensive disks accessed by a fibre channel interface;

Figure 6 shows an example of a local configuration file on the hard drive of a processing system;

Figure 7 shows an example of a network configuration file in the memory of a processing systems;

Figure 8 shows the first set of communications embodying the invention;

Figure 9 shows the second set of communications embodying the invention;

Figure 10 illustrates the primary thread shown in *Figure 8;*

Figure 11 details steps carried out in *Figure 10* to write the network configuration file;

Figure 12 details steps carried out in *Figure 11* to determine the best interface for communication;

Figure 13 shows the functions carried out by the primary thread to update the network configuration file;

Figure 14 illustrates the information-adding function shown in *Figure 13*;

Figure 15 details steps carried out in *Figure 14* to delete incorrect information from the network configuration file;

Figure 16 illustrates the information-deleting function shown in *Figure 13*;

Figure 17 illustrates the communications check responding function shown in *Figure 13*;

Figure 18 illustrates the information-supplying function shown in *Figure 13*;

Figure 19 details the termination of the primary thread;

Figure 20 shows the functions carried out by the maintenance thread;

Figure 21 illustrates the communications check function as shown in *Figure 20*;

Figure 22 details steps carried out in *Figure 21* to determine addresses to be checked;

Figure 23 illustrates the swap update function as shown in *Figure 20*;

Figure 24 details steps carried out in *Figure 23* to rewrite the network configuration file; and

Figure 25 illustrates the manual change update function as shown in *Figure 20*.

Best Mode for Carrying Out the Invention

An example of a networked image data processing environment is illustrated in *Figure 1*. The network includes eight image data processing systems **101**, **102**, **103**, **104**, **105**, **106**, **107** and **108.** Each processing system **101** to **108** has a respective frame storage disk array (hereafter referred to as a framestore) **111**, **112**, **113**, **114**, **115**, **116**, **117** and **118**. For example, each framestore **111** to **118** may be of the type obtainable from the present Assignee under the trademark "STONE" providing sixteen disks each having nine G-bytes of storage. Initially, each of the framestores is operated under the direct control of its respective processing system. Thus, framestore **111** is operated under the direct control of image data processing system **101** and framestore **113** is operated under the direct control of off-line processing system **103**, but processing systems may swap control of their respective framestores for an unlimited period of time.

The environment includes a sixteen port non-blocking fibre channel switch type **121**, such as the type made available under the trademark "GADZOOX". The switch is employed within the data processing environment to allow fast full bandwidth accessibility between each host processor **101** to **108** and each framestore **111** to **118**. Each data processing system **101** to **108** is connected to the fibre channel switch by a respective fibre cable **131** to **138**. Similarly, each framestore is connected to the fibre channel switch via a respective fibre cable **141** to **148**.

An Ethernet network **151** allows communication between the data processing systems **101** to **108** and the fibre channel switch **121.** In addition a high-bandwidth HiPPI network **152** connects processing systems **101, 102** and **103,** but not processing systems **104** to **108**. This mirrors existing operational environments, in which a processing system would be connected to a number of different networks, but not all systems would be connected to all networks. Hence, in this embodiment, processing systems **101** to **103** can communicate via a high-bandwidth network and the Ethernet, but processing systems **104** to **108** can only communicate via the Ethernet.

Within the environment, a single processing system, such as system **101**, is selected as fibre channel switch master. Under these conditions, it is not necessary for all of the processing systems to be operational but the master system **101** must be online before communication can take place through the switch. However, in most operational environments, all of the processing systems would remain operational unless taken off-line for maintenance or upgrade etc. Processing system **101** communicates with the fibre channel switch **121** over the Ethernet network **151**. Commands issued by processing system **101** to the fibre channel switch define physical switch

connections between processing systems **101** to **108** and framestores **111** to **118**.

On start-up, the fibre channel interface **121** is placed in the same condition that it was in when it was switched off. On the first start-up the switch would be placed in the default condition to the effect that each processor is connected through the switch **121** to its respective framestore. Thus, on first booting up processing system **101**, for example, it mounts framestore **111**, but if when processing system **101** was shut down it controlled framestore **117** it would mount framestore **117** again on booting up.

Thus each processing system is host to a particular framestore, which may or may not be the one which it originally controlled when the network was set up. Another processing system may only gain access to a framestore if it is allowed to do so by the processing system currently controlling that framestore. This access could be through fibre channel switch **121** or, in the case of processing systems **101** to **103**, through the high-bandwidth HiPPI network **152**.

For instance, if one of processing systems **104** to **108** requires fast access to any framestore, this must be achieved via fibre channel switch **121**. If one of processing systems **101** to **103** requires access to a framestore controlled by one of processing systems **104** to **108**, then again fast access can only be obtained via the fibre channel switch. However, if one of processing systems **101** to **103** requires access to a framestore controlled by another of **101** to **103**, then the HiPPI network is as fast as the fibre channel switch and so either could be used.

In all cases the Ethernet could theoretically be used, but it is very slow and there are no compensating advantages, so in practice data is transferred either through the fibre channel switch or through the fastest network supported by both processing systems.

Hence when a network other than the Ethernet is available to a processing system, it is necessary that the processing system is aware of which other processing systems are connected to it and which are not. The invention ensures that this happens.

An image data processing system, such as processing system **101**, is illustrated in *Figure 2*, based around an octane processor **201**. Program instructions executable within the octane processor **201** may be supplied to said processor via a data carrying medium, such as a CD ROM **202**.

Image data may be loaded locally and recorded locally via a local digital video tape recorder **203** but preferably the transferring of data of this type is performed off-line, using stations **103** to **108.**

An on-line editor is provided with a visual display unit **204** and a high quality broadcast quality monitor **205**. Input commands are generated via a ***stylus*** **206** applied to a touch table **207** and may also be generated via a keyboard **208**.

Processor **201** as shown in *Figure 2* is detailed in *Figure 3*. The processing system **201** comprises two central processing units **301** and **302**, operating in parallel. Each of these CPUs **301** and **302** has a dedicated secondary cache memory **311** and **312** that facilitates per-CPU storage of frequently used instructions and data. Each CPU **301** and **302** further includes separate primary instruction and data cache memory circuits on the same chip, thereby facilitating a further level of processing improvement. A

memory controller **321** provides a common connection between the CPUs **301** and **302** and a main memory **322**. The main memory **322** comprises two gigabytes of dynamic RAM.

The memory controller **321** further facilitates connectivity between the aforementioned components of the processor **201** and a high bandwidth non-blocking crossbar switch **323**. The switch makes it possible to provide a direct high capacity connection between any of several attached circuits, including a graphics card **324**. The graphics card **324** generally receives instructions from the CPUs **301** and **302** to perform various types of graphical image rendering processes, resulting in images, clips and scenes being rendered in real time.

A SCSI bridge **325** facilitates connection between the crossbar switch **323** and a DVD/CDROM drive **326**. The DVD drive provides a convenient way of receiving large quantities of instructions and data, and is typically used to install instructions for the processor **201** onto a hard disk drive **327**. Once installed, instructions located on the hard disk drive **327** may be transferred into main memory **322** and then executed by the CPUs **301** and **302**. An input output (I/O) bridge **328** provides an interface for the graphics tablet **207** and the keyboard **208**, through which the user is able to provide instructions to the processor **201**.

A second SCSI bridge **329** facilitates connection between the crossbar switch **323** and network communication interfaces. Ethernet interface **330** is connected to the Ethernet network **151** and first high bandwidth interface **331** is connected to the fibre channel switch **121** by connection **131**. Second high bandwidth interface **332** is connected to the HiPPI network **152**, but only on processing systems **101** to **103**. Hence the processors of processing systems

104 to **108** are identical to the processor shown in *Figure 3* except that they do not have the second high bandwidth interface **332** since they are not connected to the HiPPI network **152**.

Stored on the hard drive **327** is local configuration data **341** which contains information about the local connections of system **102**, including which framestore it currently controls and what network interfaces it supports. On starting the processor local configuration data **341** is loaded into main memory **322** as file **342**. Communications with each of processing systems **101** and **103** to **108** that are connected to the Ethernet result in a network configuration file **343** being written in memory **322**. This contains connection information about all on-line processing systems, including system **102**, and gives, for each framestore, the Ethernet address of the system which controls it and the best interface for communication.

For instance, this figure shows the processor of processing system **101**, which is connected to the HiPPI network. The best way for **101** to communicate with processing systems **102** or **103** is via the HiPPI network, but for communication with processing systems **104** to **108** it would be the Ethernet. Hence, in network configuration file **343**, a HiPPI address would be given for processing systems **102** and **103**, and an Ethernet address for each of processing systems **104** to **108**.

Local configuration data **341** must be manually written when the processing system is first connected to the network, but is automatically updated by the invention if a framestore swap occurs. It must be manually updated if the interfaces of the processing system change, but this should only occur if a system is physically unplugged from its present connections. This is envisaged to happen very infrequently and such disconnection would

only be performed by a person knowledgeable enough to update the interface information. In addition, the information would still only have to be changed in the local configuration data **341** of the affected system. The invention would ensure that all other processing systems on the network were aware of the interface change.

A plurality of video image frames **401**, **402**, **403**, **404** and **405** are illustrated in *Figure 4*. Each frame in the clip has a unique frame identification (frame ID) such that, in a system containing many clips, each frame may be uniquely identified. In a system operating with standard broadcast quality images, each frame consumes approximately one megabyte of data. Thus, by conventional computing standards, frames are relatively large. Therefore even on a relatively large disk array the total number of frames that may be stored is ultimately limited. An advantage of this situation, however, is that it is not necessary to establish a sophisticated directory system thereby assisting in terms of frame identification and access.

As a processor, for example processor **101**, boots up, it mounts its associated framestore. Stored on the hard drive of processor **101** is location data which describes the frames that are available within the framestore and in particular maps frame IDs to physical storage locations within the disk system. Thus, as illustrated in *Figure 4*, the frame with ID 561000001 is stored at location 040000, the frame with ID 561000002 is at location 04000, and so on. Thus if an application identifies a particular frame it is possible for the system to convert this to a physical location within the framestore.

A framestore, such as framestore **111**, is illustrated in *Figure 5*. The framestore **111**, connected to the fibre channel switch by fibre cable **141**, includes six physical hard disk drives, illustrated diagrammatically as drives

510, **511**, **512**, **513** and **514**. In addition to these five disks configured to receive image data, a sixth redundant disk **515** is provided.

An image field **517**, stored in a buffer within memory, is divided into five stripes identified as stripe zero, stripe one, stripe two, stripe three and stripe four. The addressing of data from these stripes occurs using similar address values with multiples of an off-set value applied to each individual stripe. Thus, while data is being read from stripe zero, similar address values read data from stripe one but with a unity off-set. Similarly, the same address values are used to read data from stripe two with a two unit off-set, with stripe three having a three unit off-set and stripe four having a four unit off-set. In a system having many storage devices of this type and with data being transferred between storage devices, a similar striping off-set is used on each system.

As similar data locations are being addressed within each stripe, the resulting data read from the stripes is XORd together by process **518**, resulting in redundant parity data being written to the sixth drive **515**. Thus, as is well known in the art, if any of disk drives **510** to **514** should fail it is possible to reconstitute the missing data by performing a XOR operation upon the remaining data. Thus, in the configuration shown in *Figure 5*, it is possible for a damaged disk to be removed, replaced by a new disk and the missing data to be re-established by the XORing process. Such a procedure for the reconstitution of data in this way is usually referred to as disk healing.

Each of these framestores shown in *Figure 5* is controlled by only one of processing systems **101** to **108**. The system which controls a framestore may access it at will, but a processing system may need images stored on a framestore which it does not control. Hence in the network environment

shown in *Figure 1* it is possible for a processing system, such as processing system **102**, to gain either temporary or permanent access to a framestore connected to another processing system, such as framestore **113**.

For example, if processing system **102** is performing a task which mainly uses images stored in its own framestore **112** but also requires some frames from framestore **113** then processing system **102** issues requests for these frames to processing system **103**, which controls framestore **113**.

If processing system **103** is able to allow access to framestore **113** then access can be achieved in one of two ways. Firstly, processing system **103** can return the locations of the requested frames to processing system **102** over Ethernet **151**. It then requests a daemon running on processing system **101** to connect processing system **102** with framestore **113** via fibre channel interface **121** for a short period of time. The second method involves processing system **103** copying the required frames and sending them, via the fastest network supported by both processing systems, to processing system **102**. In this case it would be the HiPPI network **152**.

Alternatively, if a more permanent connection is required, processing systems may swap framestores. For example, while processing system **102** is performing a task processing system **103** may be loading data necessary for the next task for processing system **102**. When processing system **102** completes the current task it swaps framestores with processing system **103** and has immediate access to the frames necessary for its next task. Processing system **103** may now archive the results of the task which processing system **102** has just completed.

Any of processing systems **101** to **108** may initiate this swap by requesting the switch-controlling daemon on processing system **101** to

connect processing system **102** with framestore **113** and processing system **103** with framestore **112** via fibre channel interface **121**. Each processing system mounts its new framestore and has complete control of it. For example, any processing system, including processing system **102**, wishing to access framestore **112** must now request this access from processing system **103**.

When this swap has occurred all other processing systems **101** and **104** to **108** must be informed, because if, for example, processing system **108** requires access to framestore **112,** it now has to request it from processing system **103,** where previously it had to contact processing system **102**.

The present system involves manual updating of a configuration file stored on each of data processing systems **101** to **108**, but the invention enables the updating to be performed by threads running on each of processing systems **101** to **108**.

The local configuration of a processing system must be manually entered on its own hard drive when it is first connected to the network. As shown in *Figure 3*, all processing systems contain local configuration data **341** on the hard drive **327,** which only contains information about the local connections. This data is parsed and read into memory as file **342** when processing system **101** starts up.

Figure 6 gives an example of such a file residing on processing system **101**, although those on the hard drives of processing systems **102** to **108** are similar. Line **601** gives the information relating to framestore **111**, the framestore which processing system **101** currently controls. (If, for example, processing system **101** had swapped with processing system **103** and now

controlled framestore **113**, then it would be framestore **113**'s details which would appear at line **601**.) 'Brazil' is the name given to framestore **111** to make distinguishing between framestores easier for users, HADDR stands for Hardware Address, which is the Ethernet address of processing system **101** which controls the framestore, and the ID, fifty-six, is the framestore identification reference (framestore ID). As shown in *Figure 4*, any frame stored within framestore **111** has a frame ID which contains the framestore ID, fifty-six. Thus when a user specifies a frame which he requires, the framestore on which it is stored is immediately known by identifying the framestore ID.

Lines **611** and **612** give information about the interfaces of processing system **101**. As shown in *Figure 1*, in this embodiment all the processing systems are connected to the Ethernet **151** and processing systems **101**, **102** and **103** are also connected by a HiPPI network **152**. In other embodiments (not shown) there may be various different networks using different protocols to which some processing systems are connected and others are not. Interfaces for every network to which a processing system is connected would be listed in that processing system's local configuration file. In *Figure 6,* line **611** describes the HiPPI interface of processing system **101** and line **612** describes the Ethernet interface. The interfaces are always listed in a certain order, the interface to the fastest network first and that to the slowest network last, thus ensuring that the first interface listed communicates with a preferred network. Hence in this example HiPPI is listed first.

PROT stands for the protocol used to communicate through an interface, so in this example 'HIPPI' means that the HiPPI protocol is used for

the HiPPI network and 'TCP' means that TCP/IP is used over the Ethernet. IADDR gives the address of the respective interfaces.

The Ethernet address hence occurs twice in the local configuration file, once as the hardware address on line **601** and once as an interface address on line **603**. This is because the FRAMESTORES and INTERFACES parts of the network configuration file **343** are used for different procedures and the local configuration data **341** must use the same structure as file **343** for ease of collating information.

When processing system **101** is switched on a thread reads local configuration data **341** into memory **322** as file **342** as shown in *Figure 6*, and also creates network configuration file **343** containing information about all other online users within the network. *Figure 7* shows an example of a network configuration file stored in the memory of processing system **101**, which contains information for the eight processing systems **101** to **108**. The network configuration files in the memory of processing systems **102** to **108** are similar to this, but contain slightly different information.

The first framestore, at line **701**, is Brazil, which *Figure 7* showed as framestore **111** connected to processing system **101**. Line **702** gives information about framestore Scotland which has ID seventy-four. For example, this may be framestore **118.** The network configuration file **343** cannot tell a user which processing system currently controls framestore **118**, but an address of that processing system is given which is all that is necessary to contact it.

Line **703** gives information about framestore Finland, which has ID seventy-two, and its controlling processing system. For example, this may be framestore **113**.

Lines **711** and **712** give the interface information for processing system **101,** listed under 'Brazil' because that is the framestore which it currently controls, as in *Figure 6.* Line **713** gives interface information for the processing system controlling 'Scotland' and line **714** gives interface information for the processing system controlling 'Finland'.

Only one interface is described for each online processing system (except the processing system on which the configuration file resides, in this case **101**). The interface given is the one for the fastest system which both processing system **101** and the processing system controlling the respective framestore support. The interface given at line **714** is an Ethernet address, implying that the system controlling framestore 'Finland' is not connected to the HiPPI network. The interface given at line **713,** however, is a HiPPI address, so the system controlling 'Scotland' is connected to the HiPPI network and hence communications between this processing system and system **101** can take place over this network rather than the slower Ethernet.

At present, a network configuration file such as **343** would have to be manually updated whenever a change occurs. The present invention ensures that file **343** is updated automatically whenever a processing system comes online, is switched off, crashes or exchanges framestores, thus guaranteeing that whenever access is needed to a framestore the correct processing system is asked for access.

In this embodiment, the invention is performed by two threads running on each of processing systems **101** to **108.** *Figures 8* and *9* illustrate the functions of these.

Figure 8 shows processing systems **101**, **102** and **103**. The two threads which embody the invention run on all processing systems but the

example in this Figure shows only three processing systems. Primary threads **801**, **802** and **803** on processing systems **101**, **102** and **103** respectively are all identical.

Processing systems **102** and **103** are already online and respectively contain in their memory files **842** and **852**, containing their local configurations, similar to file **342** shown in *Figure 6*, and network configuration files **843** and **853**, similar to network configuration file **343** shown in *Figure 7*. Each also has local configuration data on their hard drive which is not shown. Processing system **102** is connected to framestore **112**, as shown by connection **812**, and processing system **103** is connected to framestore **113**, as shown by connection **813**. Processing system **101** is off-line and therefore framestore **111** is unavailable for access, but processing system **101** and framestore **111** are connected within fibre channel switch **121** as shown by connection **811**.

When processing system **101** is switched on, local configuration data **341** stored on the hard drive is read into memory as file **342** as shown by path **825**, and then copied to become the basis for network configuration file **343** as shown by path **826**. Primary thread **801** on processing system **101** reads file **342** and announces it on the Ethernet network.

This announcement is caught by primary threads **802** and **803** on processing systems **102** and **103** respectively, as shown by paths **821** and **822**. Primary thread **802** reads file **842** and sends it to processing system **101**, as shown by path **823**, and then adds the information contained in the announcement to its network configuration file **843**. Similarly, primary thread **803** sends file **852** as shown by path **824**, and adds the information contained in the announcement to its network configuration file **853**.

Primary thread **801** on processing system **101** catches these messages and adds the information contained in them to its network configuration file **343**.

Hence processing systems **102** and **103**, which were already online, are aware of processing system **101** coming online, and are also aware of its network addresses and which framestore it controls. In addition, processing system **101** knows that systems **102** and **103** are online, knows their network addresses and which framestores they control.

Figure 9 illustrates the second thread which runs when a framestore swap occurs. As shown in *Figure 8*, processing systems **101** to **103** are connected within the framestore switch to framestores **111** to **113** respectively as shown by connections **811** to **813** respectively. A framestore swap occurs such that processing system **101** now controls framestore **112**, as shown by connection **814**, and processing system **102** is now connected to framestore **111** as shown by connection **815**.

A second thread, shown as maintenance thread **901** on processing system **101** and maintenance thread **902** on processing system **102**, receives a message from the swap utility **911** which informs it of its new framestore. In this example the swap utility **911** has been carried out on processing system **101**, but it can run on any of processing systems **101** to **108**, regardless of which systems are actually involved in the swap. In this case swap process **911** announces the swap to processing system **102**, as shown by path **921**, and effectively announces it to its own processing system **101** as shown by path **922**. Maintenance threads **901** and **902** update their respective local configuration data **341** and **841**, reread them into memory as files **342** and **842**, as shown by paths **923** and **924**, and change

their respective network configuration files **343** and **853**.

Maintenance threads **901** and **902** then announce their new configurations on the Ethernet. Primary threads **802** and **803** catch the announcement by thread **901**, as shown by paths **925** and **926** respectively, and threads **801** and **803** catch the announcement by thread **902**, as shown by paths **927** and **928** respectively. Primary threads **801**, **802** and **803** then update their respective network configuration files **343**, **843** and **853**. Hence each processing system is now aware that the swap has taken place, and each local and network configuration file is correct.

Both the primary and maintenance threads have other duties which will be enlarged upon later.

Figure 10 shows the basic process of primary thread **801** on processing system **101**. Threads **802** and **803** on processing systems **102** and **103** are identical to **801**, as are threads on each of processing systems **104** to **108**. The thread starts when the processor is switched on and at step **1001** a start up process is performed which writes network configuration file **343**.

At step **1002** various functions are performed which keep the network configuration file accurate if the network structure changes, and at step **1003** the thread terminates when the processor is switched off.

Figure 11 details step **1001**, the process which occurs when processing system **102** is switched on. At step **1101** local configuration data **341** is read into memory **322** as local configuration file **342** and at step **1102** the information contained in file **342**, together with a message notifying that the processing system sending the message is online, is multicast on the network. A multicast is a message sent to all users on the network whose

Ethernet address starts with a certain sequence of digits, so when this network was set up it would be configured so that all processing systems connected to a particular fibre channel switch have an address starting in the same way. Hence a processing system can easily be added to the network since as long as its address starts in a particular way it will receive the multicasts.

In this embodiment processing systems **101** to **108** are the only systems in the network, but in an alternative embodiment (not shown) there is a large network of processing systems within which there is a number of 'sub-networks', each arranged around one of several fibre channel switches. Within each of these sub-networks all the processing systems have Ethernet addresses which start in the same way and differently from any system on a different sub-network. Setting up a network in this way and using multicasts ensures that processing systems only receive information which is relevant to them. It also means that, if necessary, a processing system can be moved between sub-networks simply by changing its Ethernet address.

At step **1103** responses are received from all processing systems within the network which received the multicast and which are switched on. These responses are in the form of unicasts, which are messages sent only to one processing system. Each of these unicasts comprises the information contained in the local configuration file in the memory of the processing system which sent it. Hence each processing system which is connected to the fibre channel switch and which is online has sent its local configuration information to processing system **102**.

At step **1104** file **342** is copied to become the basis for network configuration file **343** and at step **1105** the question is asked as to whether

any responses were received at step **1103**. If no other processing systems are switched on then no unicasts will have been received in response. This is unlikely, as processing system **101** must be online in order for the fibre channel switch to be operated and, as observed before, in most environments all of the processing systems would remain operational unless taken off-line for a specific reason, but it is possible, so if the question asked at step **1105** is answered in the negative then step **1001** is completed since there is no information to add to network configuration file **343**.

If the question asked at step **1105** is answered in the affirmative, then at step **1106** the information contained in the first received unicast is added to file **343**. At step **1107** the question is asked as to whether another unicast has been received. If this question is answered in the affirmative then control is returned to step **1106** and the next unicast is added to file **343**. Eventually, all responses will have been processed and the question asked at step **1107** will be answered in the negative. At this point, network configuration file **343** is complete and gives an accurate picture of the network.

As shown in *Figure 7*, all available framestores are listed first under FRAMESTORES, together with the Ethernet addresses of the processing systems to which they are connected and their IDs. Each framestore is listed again under INTERFACES together with the preferred interface information of the processing system to which it is connected. If a processing system is not online then the framestore which is controls is not available, so no reply will have been received from that processing system and its framestore will not be listed in the network configuration file.

If no unicasts were received at step **1103** then network configuration file **343** will include only the information within the local configuration file **342**.

When a user of a processing system specifies frames to which he requires access the application he is using looks at the framestore ID contained within the frame IDs. It searches for that framestore ID in the INTERFACES section of network configuration file **343**, and so checks whether the framestore is available for access, and then determines the address to which the requests for access should be sent.

The information listed under FRAMESTORES is used when a swap of framestores takes place. When this occurs the location data given in *Figure 4* must also be swapped between the processing systems and in this case the Ethernet must be used, and so it is only the Ethernet addresses which are listed in this section.

Figure 12 details step **1106** which adds information contained in a message (a unicast or multicast) to network configuration file **343**. These messages contain the local configuration file of the sender, similar to that shown in *Figure 6*. At step **1201** the INTERFACES information contained in the message is read to identify the first listed protocol. As previously stated, the interfaces are listed by the speed and hence desirability of the networks to which they connect. Hence if the first protocol listed in the message matches a protocol listed in file **342**, this is the interface which will be used for communication. If the first protocol does not match then the second is checked and so on. There will always be a protocol which matches because all processing systems are connected by the Ethernet.

Hence at step **1202** the question is asked as to whether the identified protocol is listed in file **342**. If this question is answered in the negative then control is returned to step **1201** and the next protocol is identified.

If the question is answered in the affirmative then at step **1203** the question is asked as to whether the addresses for that protocol 'match', ie whether they start in a similar way. A protocol may be used for more than one network and hence when a matching protocol is found it must be checked that the networks do also. Hence if the addresses do not start in the same way they are addresses for different networks using the same protocol, and so if the question is answered in the negative then control is returned to step **1201** and the next protocol is identified.

If the question asked at step **1203** is answered in the affirmative then the fastest network which both processing systems support has been found. Thus at step **1204** the message is once more read and the information under FRAMESTORES and the single line of information under INTERFACES which refers to the last checked protocol are written to network configuration file **343**. The message has now been added to the network configuration file.

The functions performed at step **1002** are detailed in *Figure 13*.

Function **1301** adds information to network configuration file **343** when another processing system joins the network or changes its local configuration data in any way.

Function **1302** deletes information from the network configuration file **343** when a processing system shuts down or swaps framestores.

Function **1303** responds to communications checks to confirm processing system **101** is still online. Maintenance thread **901** sends out similar communications checks as shown in *Figure 21*.

Function **1304** provides applications running on processing system **102** with accurate information about which framestores are connected to which processing systems.

Function **1301** is detailed in *Figure 14*. At step **1401** a multicast is received from a processing system, say processing system **103**, which has just been switched on. This is in the same form as the multicast sent by processing system **102** at step **1102**. It contains the local configuration information of processing system **103** together with a message that the system sending the multicast is online.

At step **1402** the Ethernet address of the transmitting system is read from the FRAMESTORES section of the multicast and at step **1403** the information contained in file **342** in the memory **402** of processing system **102** is unicast back to processing system **103**.

At step **1404** any entries which conflict with the information just received are removed from network configuration file **343**. There will not be conflicting information if the multicast has been sent by a processing system just coming online, but there will be when a framestore swap occurs. In this case there will already be entries for each framestore but the interfaces will be wrong.

At step **1404** the information contained in the multicast is added to network configuration file **343**, in exactly the same way that information contained in responding unicasts received at step **1103** was added to the network configuration file at step **1104,** as detailed in *Figure 12*.

Thus the network configuration file on each processing system is updated whenever any other processing system within the network is switched on or multicasts out changed details.

Figure 15 details step **1404** at which entries which conflict with the received information are deleted. At step **1501** the message is read and the framestore ID contained within it is identified.

At step **1502** the question is asked as to whether this ID is contained within network configuration file **343**. If this question is answered in the affirmative then at step **1503** the entries under FRAMESTORES and under INTERFACES corresponding to this ID are removed.

At this point, and if the question asked at step **1502** is answered in the negative, control is directed to step **1504** at which the Ethernet address contained in the multicast is identified. At step **1505** the question is asked as to whether this address is contained within network configuration file **343**. It is necessary for this question to be asked even if the framestore ID was not contained in the network configuration file, since it is possible for an Ethernet address to already be in a network configuration file but not the ID, or vice versa, since a new processing system or framestore could have been connected to an existing framestore or processing system.

If the question asked at step **1505** is answered in the affirmative then the entries under FRAMESTORES and under INTERFACES which correspond to the Ethernet address should be deleted. However, since it may not be the Ethernet address but a different one which appears in the INTERFACES section, the framestore ID linked with the Ethernet address is identified at step **1506** by examining the FRAMESTORES section of network configuration file **343.** At step **1507** the information corresponding to that ID in both sections is deleted.

Figure 16 details function **1302** which deletes information from the network configuration file when a processing system shuts down or swaps framestores. At step **1601** a multicast is received containing information that a particular processing system, say system **104**, is offline. This is in the same form as a multicast sent when a system switches on in that it contains the

local configuration file of processing system **104**, except that the extra message contained indicates that the system sending the multicast is offline rather than online. No unicast is sent in response to this multicast.

At step **1602** the Ethernet address of the transmitting system, in this case processing system **104**, is read from the FRAMESTORES section of the multicast.

At step **1603** the process examines the FRAMESTORES part of network configuration file **343** on processing system **101** and identifies the framestore which is linked with the address of processing system **104**, identified at step **1602**. At step **1604** the information about this framestore under FRAMESTORES and under INTERFACES is deleted from the file. Thus the network configuration file on each processing system is updated whenever any other processing system shuts down.

Figure 17 details process **1303** which responds to a communications check. At step **1701** a communications check unicast is received, say from processing system **105**, which contains only the Ethernet address of the sending processing system. This is a check by system **105** to ensure that processing system **101** is still online and has not crashed. At step **1702** a replying unicast is sent to processing system **105**. Checks of this kind are sent out from processing system **101** by maintenance thread **901**, as shown in *Figure 21*.

Figure 18 details function **1304** which supplies information to applications running on processing system **101**. At step **1801** a request for information is received in the form of a time and date. This is the modification date of the file which the application currently holds. (If an application has not requested information before, the date sent will be midnight at 01 January

2000.)

At step **1802** the question is asked as to whether this time and date is the same as the modification time and date of network configuration file **343**. If this question is answered in the negative then the network configuration file has been updated since the last time the information was sent to the application, and so at step **1803** the information contained under INTERFACES within network configuration file **343** is sent to the application.

If the question asked at step **1802** is answered in the affirmative then no updates have taken place and the information the application has is still correct. In this case, control is directed to step **1804** at which a message 'NO UPDATE' is sent to the application.

In this way, applications are supplied with up to date with information when they need it. The information is required when a user wishes to access information stored on a framestore to which he is not connected. When a processing system requests access to another framestore this request may be sent by the fastest route possible, which is why it is the interface to the fastest network which is listed under INTERFACES and sent to the applications.

Figure 19 details step **1003**, the termination of primary thread **801**. This only occurs when processing system **101** is shut down for any reason, so at step **1901** the thread receives notice that the processor is going to shut down.

At step **1902** a multicast is sent out containing the file **342** stored in the memory **342** of processing system **101,** together with a message that the system is going offline, similar to that received from processing system **104** at step **1601**, so that all other processing systems can remove the framestore

controlled by processor **101** from their respective network configuration files. No responses are received to this multicast.

At step **1903** thread **801** terminates. Since the network configuration file **343** is stored in memory **322** it is lost when the processor switches off, similarly for file **342**. Hence there is no old information to conflict with the correct network configuration when the processor next starts up and loads the local configuration data **341** from the hard drive **327**.

Figure 20 shows the functions of maintenance thread **901**. This thread runs on each of processing systems **101** to **108** but in this example runs on processing system **101**.

Function **2001** is the sending out of communications checks to ensure that other processing systems are still online.

Function **2002** rewrites the local and network configurations **341** and **343** whenever a framestore swap occurs between processing system **101** and any other system.

Function **2003** rewrites network configuration file **343** if for any reason local configuration data **341** is manually changed.

Figure 21 details process **2001** at which communication checks are sent out. At step **2101** the FRAMESTORES part of network configuration file **343** is read to identify the Ethernet addresses of all online processing systems. The first address is ignored as this is the address of processing system **101** itself.

At step **2102** the question is asked as to whether the network configuration file contains any addresses, apart from the address of system **101**. If this question is answered in the negative then no communications check is necessary since no other processing systems are online, and so

control is directed to step **2109** at which the process waits for a specified length of time, which in this example is five minutes, before trying again.

If the question asked at step **2102** is answered in the affirmative then at step **2103** communications checks are sent to all addresses which have not been 'seen', ie with which there has been no communication in the last five minutes. If there has been communication then a communication check is unnecessary. If all systems have been 'seen' then no unicasts will be sent, so at step **2104** the question is asked as to whether any communications checks were made. If this question is answered in the negative then control is directed to step **2109** at which the process waits for five minutes before returning to step **2101**.

If the question asked at step **2104** is answered in the affirmative then at step **2105** responses are received from the checked addresses.

At step **2106** the question is asked as to whether replies were received from all the addresses to which checks were sent. If this question is answered in the affirmative then control is directed to step **2109** where the process waits for five minutes. If the question is answered in the negative then at step **2107** the process examines the FRAMESTORES part of the network configuration file to identify the framestores linked with the addresses which did not respond. The information corresponding to these framestores under FRAMESTORES and under INTERFACES is deleted from the network configuration file at step **2108**.

At step **2109** the process waits. After waiting for five minutes control is returned to step **2101** and the process starts again.

Figure 22 details step **2103** at which communications checks are sent out. Every time a multicast or unicast is received from a processing system

this is logged so that unnecessary checks are not sent to systems which have recently communicated. Whichever network is used for the message, it is the corresponding Ethernet address which is logged. Hence at step **2201** the question is asked as to whether the first Ethernet address identified at step **2101** has been 'seen', ie logged, since the last communications check.

If this question is answered in the negative then at step **2202** a communications check is sent to that address. The check takes the form of a unicast which only contains the Ethernet address of the sender, similar to that received at step **1701**. This prompts the receiving processing system to send a unicast in reply containing its Ethernet address, similar to that sent at step **1702**.

If the question asked at step **2201** is answered in the affirmative, ie the address has been 'seen' recently, then control is directed to step **2203** at which the question is asked as to whether there is another address to check. If this question is answered in the affirmative then control is returned to step **2201** and the next address is checked. If it is answered in the negative then all necessary communications checks have been sent.

The communications check ensures that if a processor crashes then every processing system in the network is made aware that a particular processing system is no longer contactable. If a processor crashes then the framestore which it controls is not available for access, so it should be removed from the network configuration file.

Figure 23 details function **2002**, the rewriting of the configuration files when a framestore swap occurs.

At step **2301** a unicast is received from swap utility **911**, which could be running on any processing system but in this example is running on

processing system **101**. This contains the name and ID of the framestore which processing system **101** now controls. A similar unicast is sent to the other processing system taking part in the swap, in this example processing system **102**.

At step **2302** a message is sent to a request daemon running on processing system **101** which catches requests for remote access to the framestore which system **101** controls. This message instructs the daemon to turn away all requests until further notice. This is because until the network configuration files on processing systems **102** to **108** are updated they will be sending requests for access to framestore **111** to processing system **101**, but framestore **111** is now controlled by processing system **102** and so the requests cannot be honoured.

At step **2303** local configuration data **341** is rewritten by replacing the framestore name and ID contained within it with the new name and ID received from swap utility **911**. At step **2304** data **341** is reread into memory as local configuration file **342** replacing the existing file.

At step **2305** the network configuration file is rewritten and at step **2306** local configuration file **342** is multicast onto the Ethernet so that all other processing systems know of the change.

At step **2307** the request daemon is instructed to allow requests for access since processing systems **102** to **108** will now be sending requests to the correct processing system.

Figure 24 details step **2305** at which network configuration file **343** is rewritten. At step **2401** the information about the first listed framestore is deleted, under both FRAMESTORES and INTERFACES. This is always the information about the framestore which processing system **101** controls and it

has now changed.

At step **2402** the framestore ID of the framestore which processing system **101** now controls is identified from local configuration file **342** and at step **2403** the entries under FRAMESTORES and INTERFACES corresponding to that ID are deleted. The information about this ID relates to the processing system with which processing system **101** has swapped and is now incorrect.

At step **2404** the information contained in local configuration file **342** is copied in and network configuration file **343** is now up-to-date and may be multicasted at step **2306**.

Figure 25 illustrates function **2003**. This runs when a user updates local configuration data **341**, for instance because interface information has changed.

At step **2501** thread **901** receives notice that the local configuration has changed. This is a message triggered by the saving of the local configuration data. At step **2502** the local configuration data is reread into memory as file **342**.

At step **2503** the information about the first listed framestore, ie that controlled by processing system **101**, is deleted from network configuration file **343**, as at step **2401**, and at step **2504** the information from local configuration file **342** is read in.

At step **2505** the network configuration file is multicasted out on the Ethernet so that all other processing systems know of the change.

Claims

1. Image data processing apparatus, comprising a plurality of image processing systems in which each of said image processing systems has direct access to a respective frame storage means; and

a network connecting said image processing systems together so as to allow each connected image processing system to indirectly access the frame storage means of the other connected image processing systems; wherein

each image processing system includes a local configuration file specifying details of its respective locally connected storage means,

a network configuration data structure, and

network communication means; wherein, said network communication means is arranged to

transmit details of its associated configuration file to other networked image systems, and to

add configuration data to its associated network configuration data structure in response to configuration details received from other networked image processing systems.

2. Apparatus according to claim **1**, wherein said data processing systems are based around a silicon graphics O_2, Octane or Onyx2 computer.

3. Apparatus according to claim **1**, wherein said data storage systems include a plurality of disks configured to receive image stripes.

4. Apparatus according to claim **3**, including redundant disks to provide data security.

5. Apparatus according to claim **4**, wherein said disks are configured as a redundant array of inexpensive disks (RAID).

6. Apparatus according to claim **1**, wherein said network includes a high bandwidth switching means.

7. Apparatus according to claim **6**, wherein said high bandwidth switching means is a fibre channel switch.

8. Apparatus according to claim **1**, wherein said network communication means is an Ethernet network.

9. Apparatus according to claim **1**, including a local disk drive, wherein said configuration data is stored on said local disk drive.

10. Apparatus according to claim **1**, including the high bandwidth fibre channel switch and a low bandwidth Ethernet, wherein image data is transferred over said high bandwidth fibre channel switch and said configuration data is transferred over said Ethernet.

11. A method of automatically writing network configuration data structures in a networked image data processing environment, including a

plurality of image processing systems in which each of said image processing systems has direct access to a respective frame storage means, wherein each image processing system includes a local configuration file specifying details of its respective locally connected storage means, a network configuration data structure, and network communication means; and a network connecting said image processing systems together so as to allow each connected image processing system to indirectly access the frame storage means of the other connected image processing systems; wherein said method performs the steps of:

transmitting details of system configuration data to other networked processing systems, and

adding configuration data to a local network configuration data structure in response to configuration details received from other networked image processing systems.

12. A method according to claim **11**, configured for execution upon a silicon graphics O_2, Octane or Onyx2 to computer.

13. A method according to claim **11**, wherein image frames are divided into a plurality of stripes and said stripes are directed to respective disk storage devices.

14. A method according to claim **13**, including a process of generating redundant data and supplying said redundant data to a redundant disk thereby providing a degree of security.

15. A method according to claim **14**, wherein said disks are arranged as a redundant array of inexpensive disks (RAID).

16. A method according to claim **11**, wherein said network includes a high bandwidth switching means.

17. A method according to claim **16**, wherein said high bandwidth switching means is a fibre channel switch.

18. A method according to claim **11**, wherein said network communication means is an Ethernet network.

19. A method according to claim **11**, wherein said configuration data is stored on a local disk drive.

20. A method according to claim **11**, wherein image data is transferred over a high bandwidth fibre channel switch and configuration data is transferred over an Ethernet network.

21. A computer readable medium having computer readable instructions executable by a computer such that, when executing said instructions, a computer will perform the steps of:

transmitting details of configuration data to other computer systems executing similar instructions and

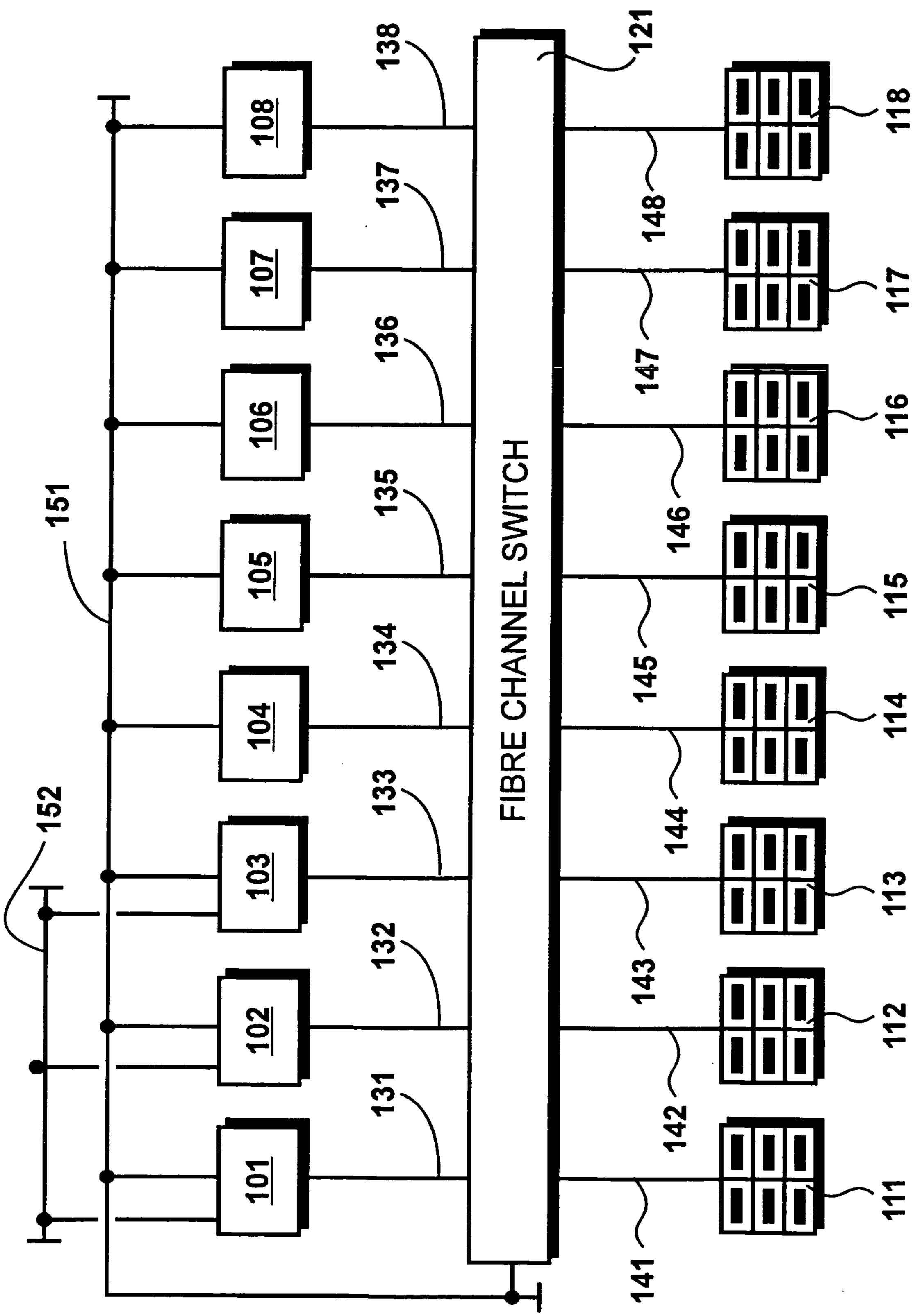
upon receiving transmitted configuration data from another system, adding said configuration data to a local network configuration data structure.

Abstract of the Disclosure

Image Processing

Network configuration data is automatically written to data structures in a networked image data processing environment. The environment includes several image processing systems (**101-108**) in which each image processing system has direct access to a respective frame storage device (**111-118**). Each image processing system includes a local configuration file specifying details of its locally connected storage device in combination with a network configuration data structure. A network (**121**) allows each image processing system to indirectly access the frame storage devices of other connected image processing systems. An image processing system transmits details of system configuration data to other networked processing systems. Furthermore, configuration data received from other networked image processing systems is added to local configuration data. Thus, when network configurations are changed, each system will identify its local condition, transmit this information to other systems and receive information from the other systems.

(*Figure 1*)



FIBRE CHANNEL SWITCH
121
101
102
103
104
105
106
107
108
111
112
113
114
115
116
117
118
131
132
133
134
135
136
137
138
141
142
143
144
145
146
147
148
151
152

Figure 1

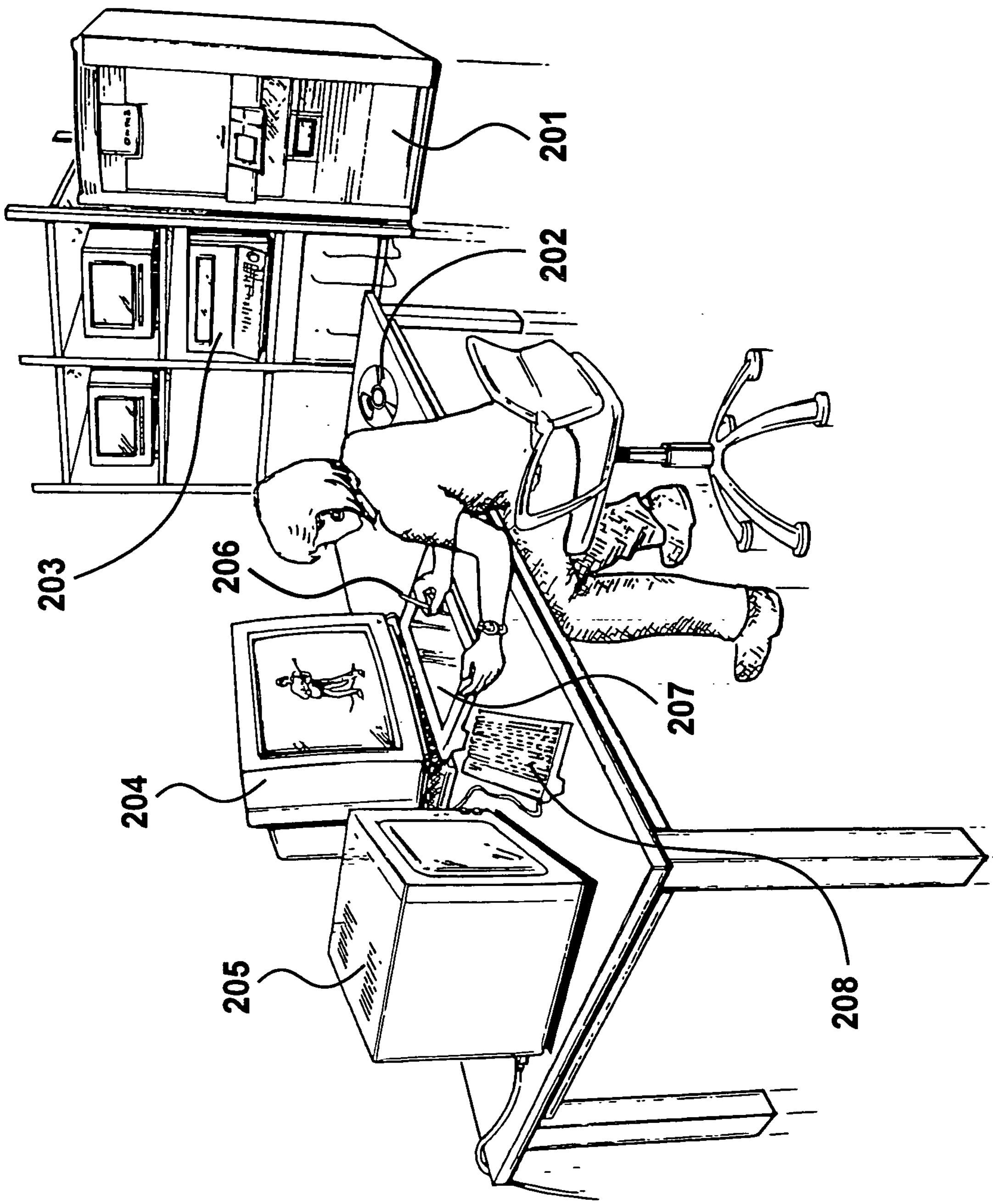


Figure 2

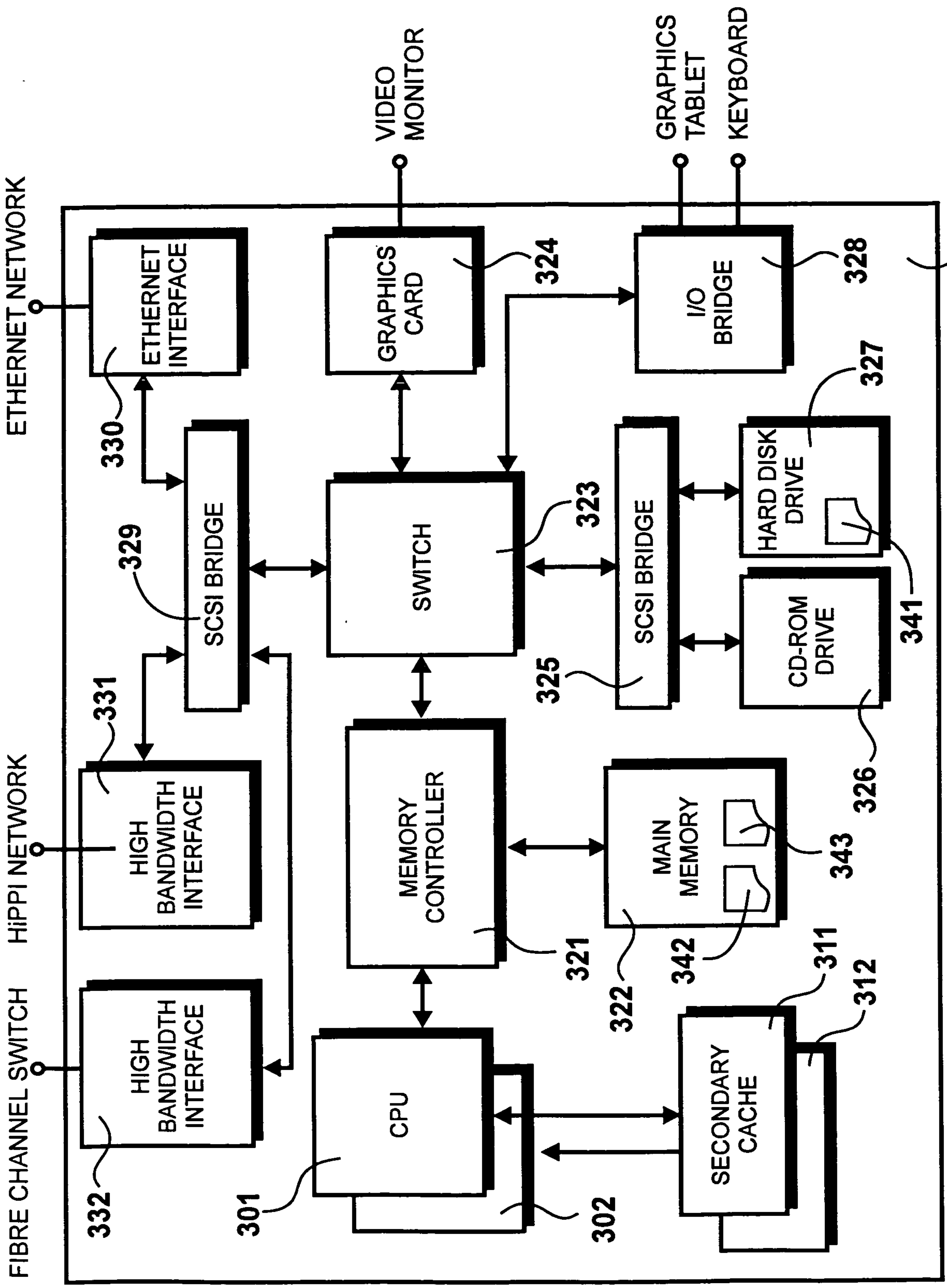
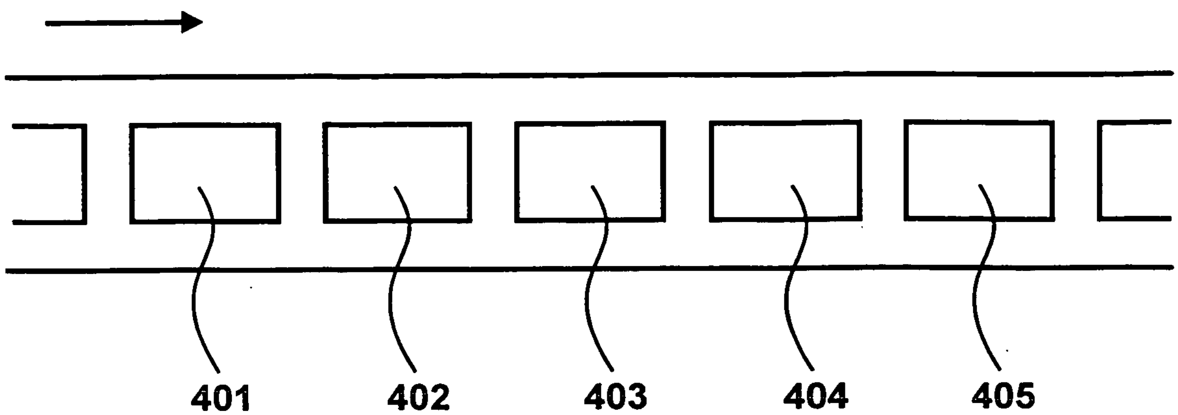

ETHERNET NETWORK
VIDEO MONITOR
GRAPHICS TABLET
KEYBOARD
HiPPI NETWORK
FIBRE CHANNEL SWITCH
ETHERNET INTERFACE
GRAPHICS CARD
I/O BRIDGE
SCSI BRIDGE
SWITCH
SCSI BRIDGE
HARD DISK DRIVE
CD-ROM DRIVE
HIGH BANDWIDTH INTERFACE
MEMORY CONTROLLER
MAIN MEMORY
HIGH BANDWIDTH INTERFACE
CPU
SECONDARY CACHE
330
329
331
332
301
302
324
323
325
321
322
342
343
328
327
341
326
311
312
201

Figure 3



FRAME ID	STORAGE LOCATION
561000001	040000
561000002	040001
561000003	040002
561000004	040003
561000005	040004

Figure 4

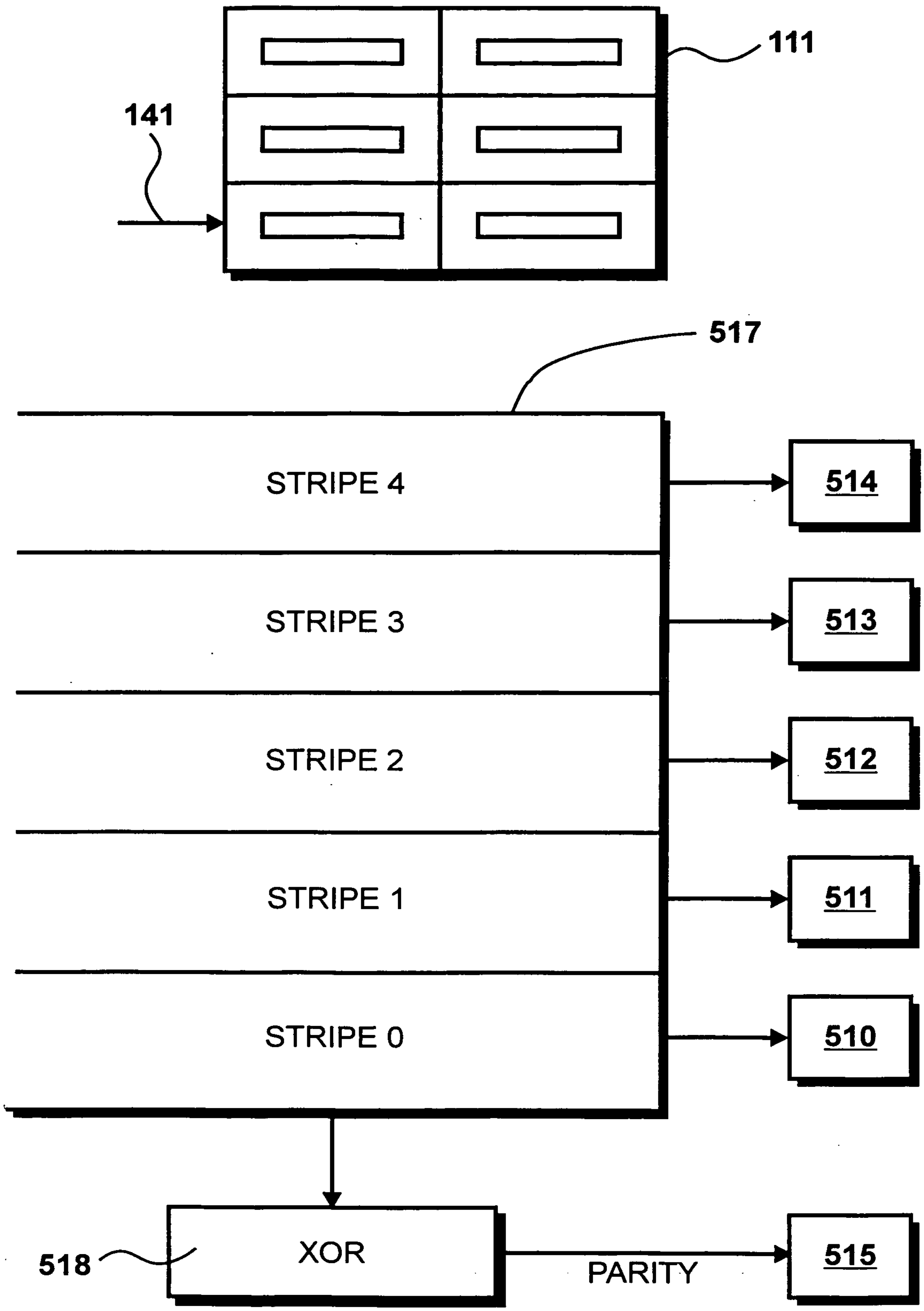

111
141
517
STRIPE 4
STRIPE 3
STRIPE 2
STRIPE 1
STRIPE 0
514
513
512
511
510
518
XOR
PARITY
515

Figure 5

```
     [FRAMESTORES]
601  FRAMESTORE=BRAZIL       HADDR=192.168.25.56   ID=56

     [INTERFACES]
     FRAMESTORE=BRAZIL
611  PROT=HIPPI              IADDR=Ox03000003
612  PROT=TCP                IADDR=192.168.25.56
```

341

Figure 6

```
      [FRAMESTORES]
701 ~ FRAMESTORE=BRAZIL      HADDR=192.167.25.56  ID=56
702 ~ FRAMESTORE=SCOTLAND    HADDR=192.167.25.74  ID=74
703 ~ FRAMESTORE=FINLAND     HADDR=192.167.25.72  ID=72
      FRAMESTORE=AUSTRIA     HADDR=192.167.25.54  ID=54
      FRAMESTORE=SYRIA       HADDR=192.167.25.64  ID=64
      FRAMESTORE=KUWAIT      HADDR=192.617.25.42  ID=42
      FRAMESTORE=BOLIVIA     HADDR=192.167.25.65  ID=65
      FRAMESTORE=ARGENTINA   HADDR=192.167.25.52  ID=52

      [INTERFACES]
      FRAMESTORE=BRAZIL
711 ~ PROT=HIPPI             IADDR=Ox03000003
712 ~ PROT=TCP               IADDR=192.167.25.56
      FRAMESTORE=SCOTLAND
713 ~ PROT=HIPPI             IADDR=Ox03000001
      FRAMESTORE=FINLAND
714 ~ PROT=TCP               IADDR=192.167.25.72
      FRAMESTORE=AUSTRIA
      PROT=TCP               IADDR=192.167.25.54
      FRAMESTORE=SYRIA
      PROT=TCP               IADDR=192.167.25.64
      FRAMESTORE=KUWAIT
      PROT=HIPPI             IADDR=Ox03000002
      FRAMESTORE=BOLIVIA
      PROT=TCP               IADDR=192.167.25.65
      FRAMESTORE=ARGENTINA
      PROT=TCP               IADDR=192.167.25.52
```

343

Figure 7

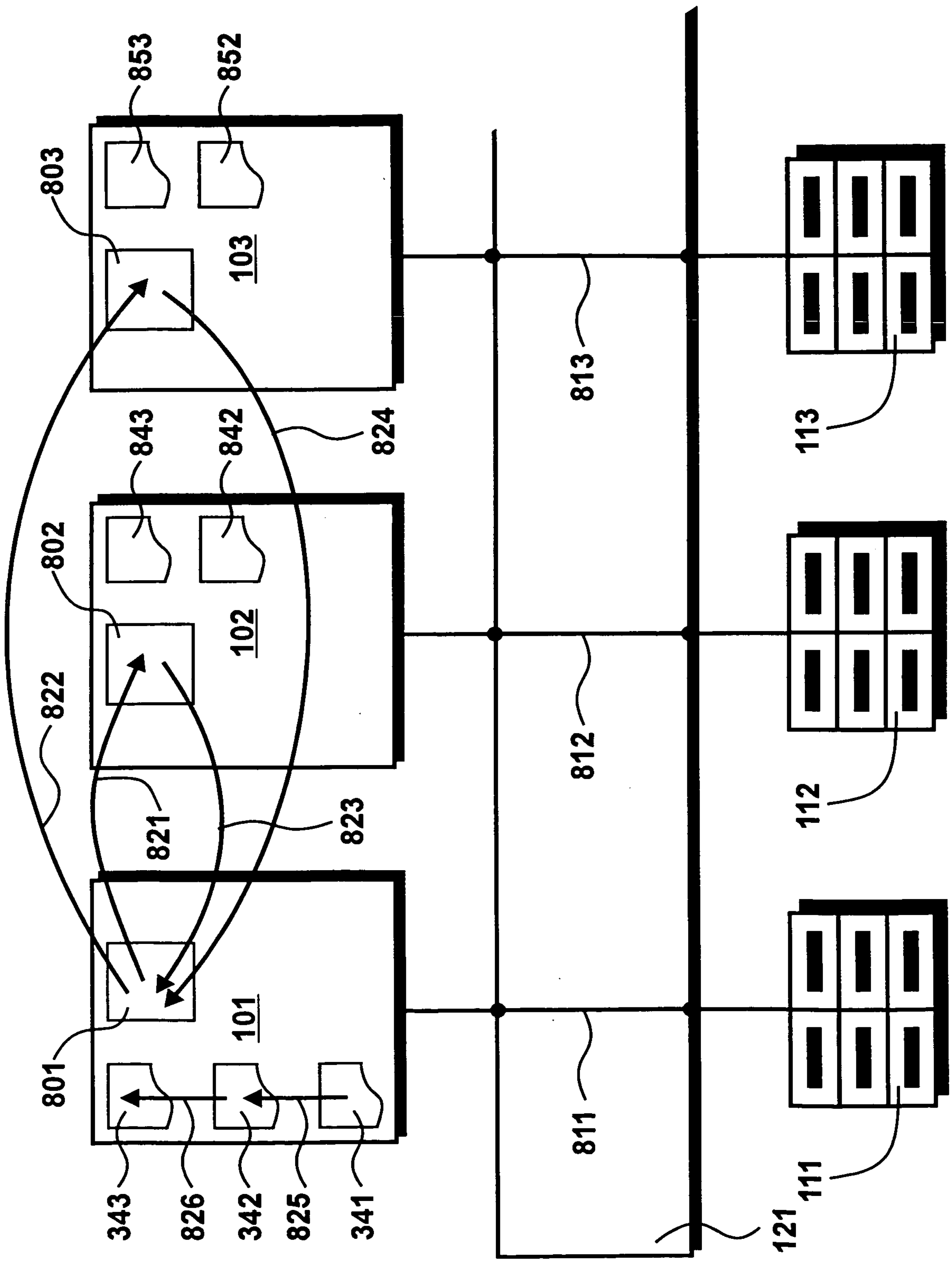

853
852
803
103
843
842
824
813
113
802
102
822
821
823
812
112
801
101
811
343
826
342
825
341
121
111

Figure 8

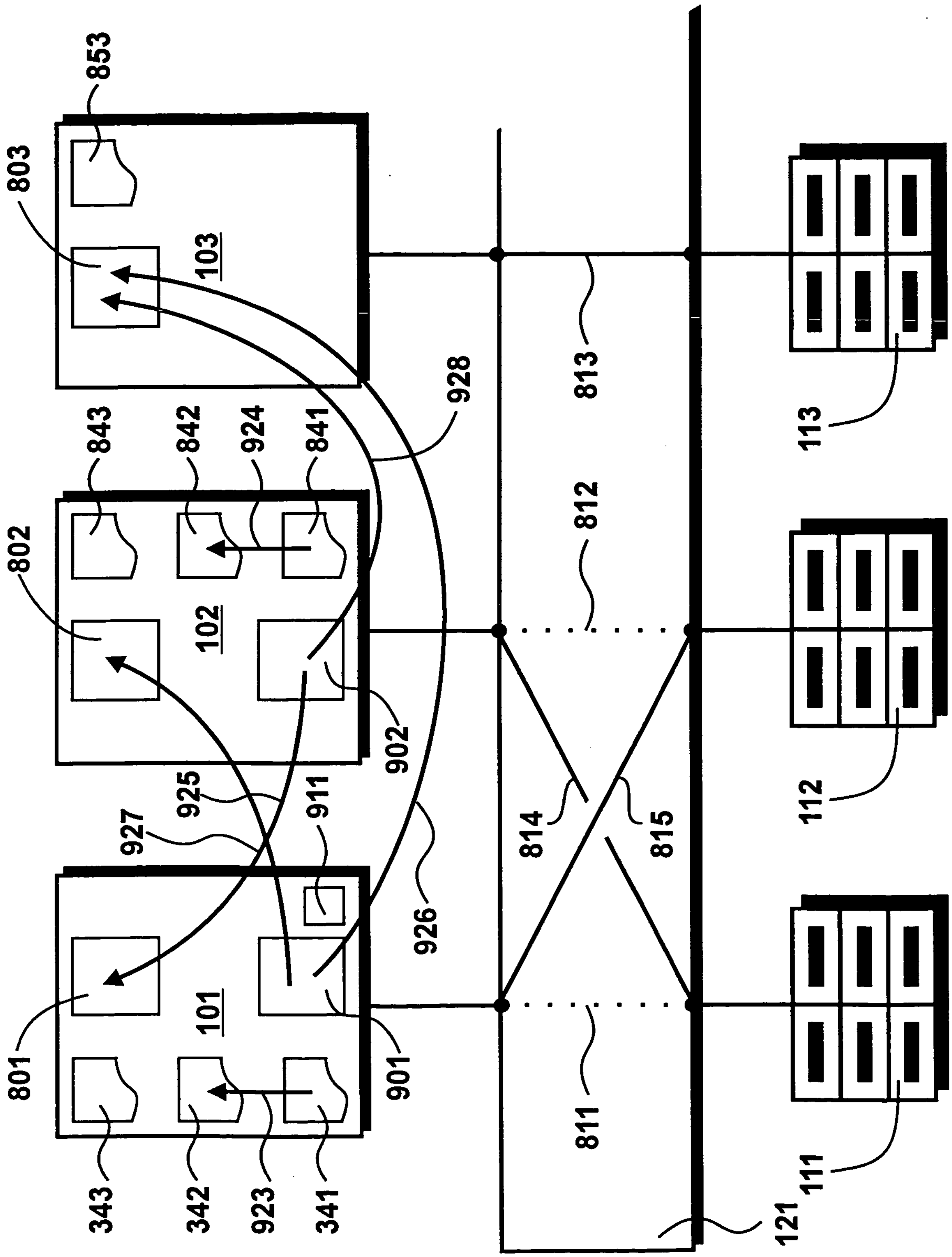

853
803
103
843
842
924
841
802
102
928
813
812
113
902
925
911
927
926
814
815
112
801
101
901
343
342
923
341
811
121
111

Figure 9

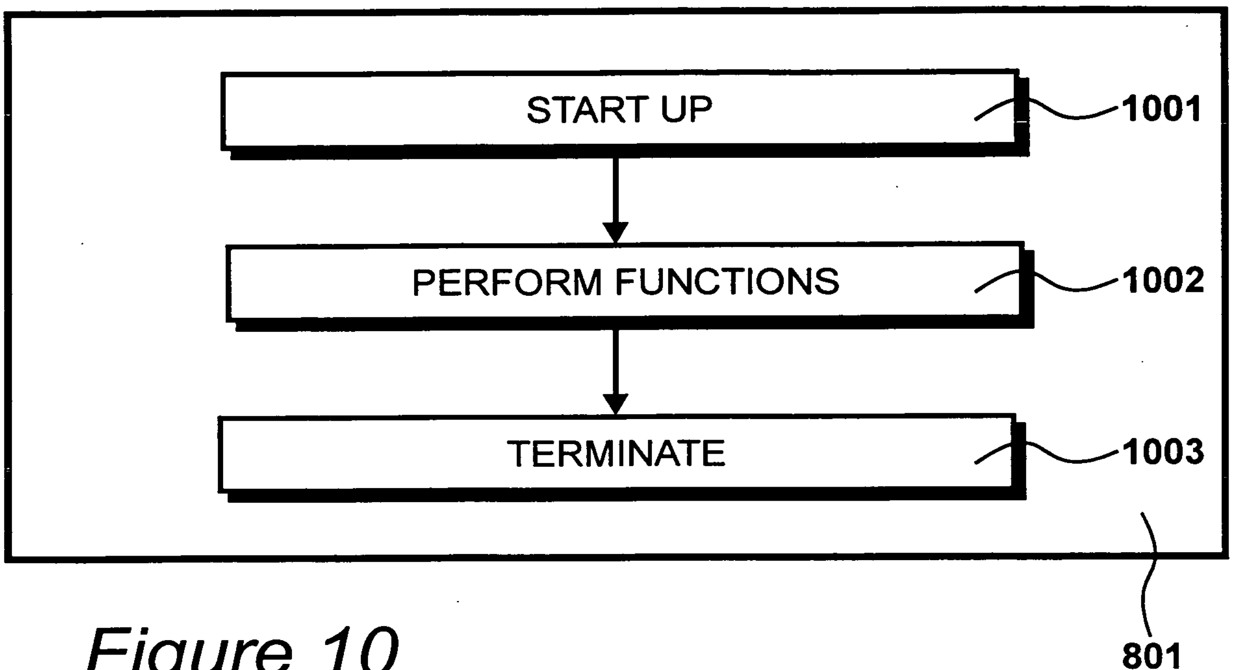


Figure 10

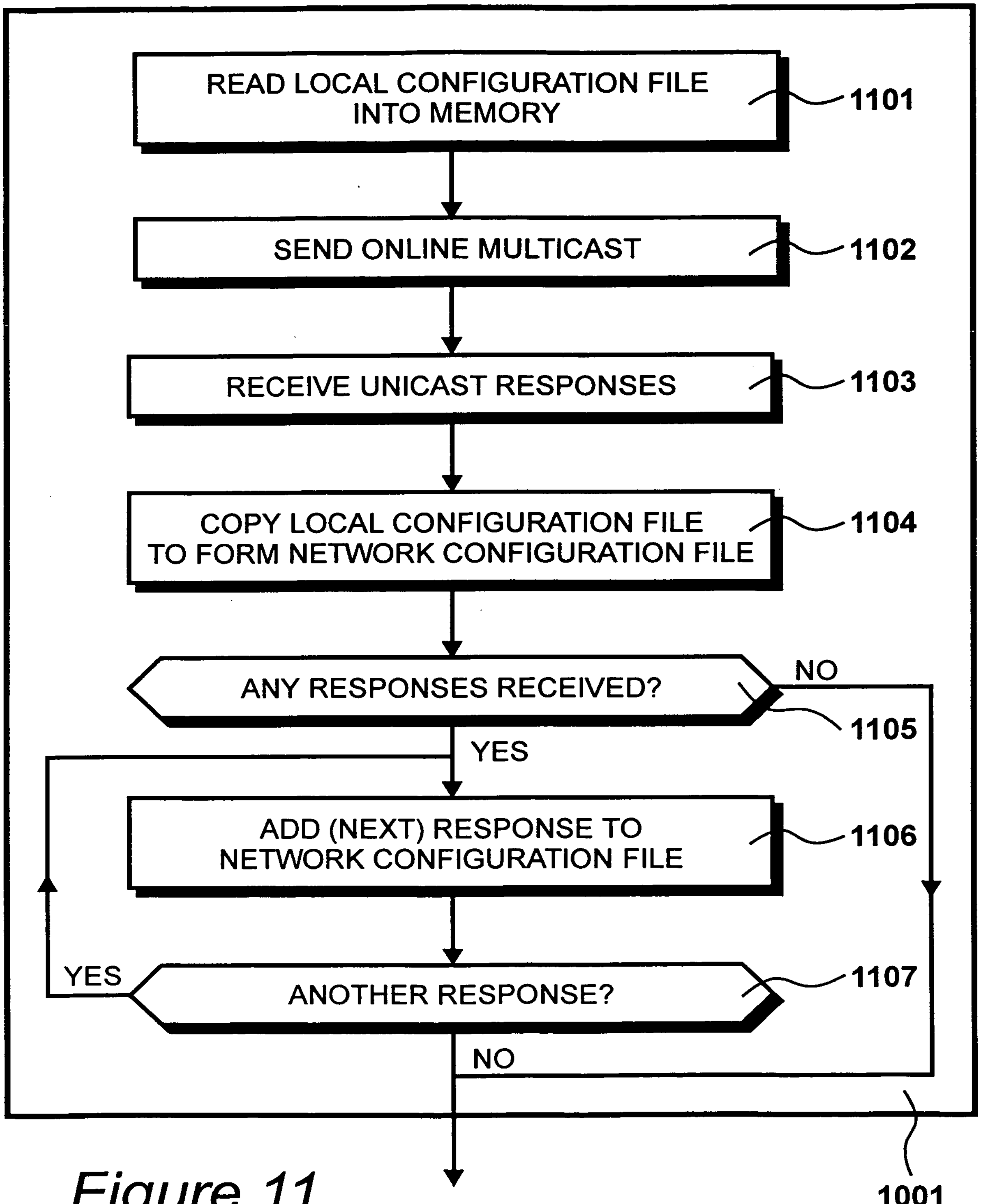

READ LOCAL CONFIGURATION FILE INTO MEMORY
1101
SEND ONLINE MULTICAST
1102
RECEIVE UNICAST RESPONSES
1103
COPY LOCAL CONFIGURATION FILE TO FORM NETWORK CONFIGURATION FILE
1104
ANY RESPONSES RECEIVED?
NO
1105
YES
ADD (NEXT) RESPONSE TO NETWORK CONFIGURATION FILE
1106
YES
ANOTHER RESPONSE?
1107
NO
1001

Figure 11

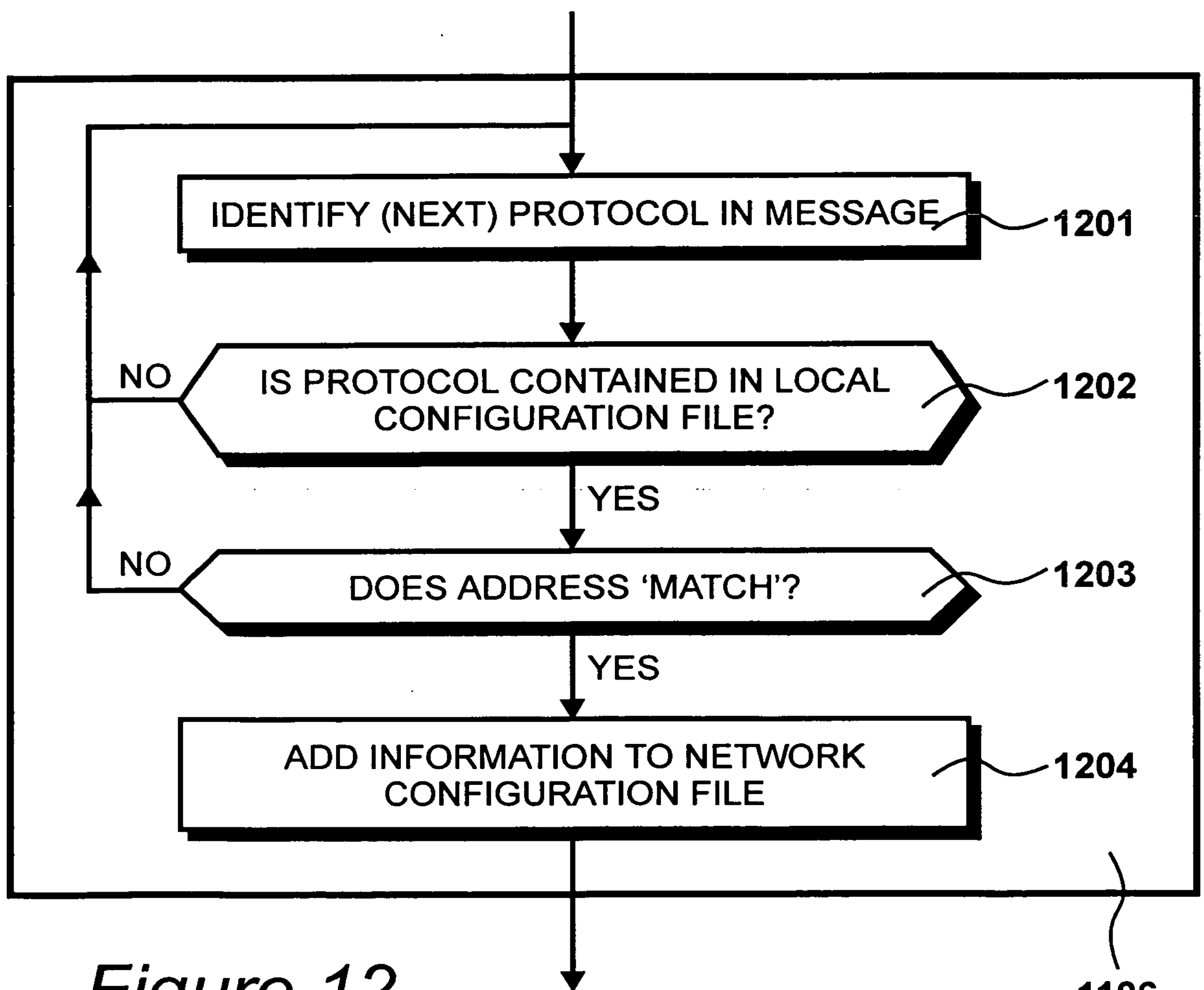

IDENTIFY (NEXT) PROTOCOL IN MESSAGE
1201
NO
IS PROTOCOL CONTAINED IN LOCAL CONFIGURATION FILE?
1202
YES
NO
DOES ADDRESS 'MATCH'?
1203
YES
ADD INFORMATION TO NETWORK CONFIGURATION FILE
1204
1106

Figure 12

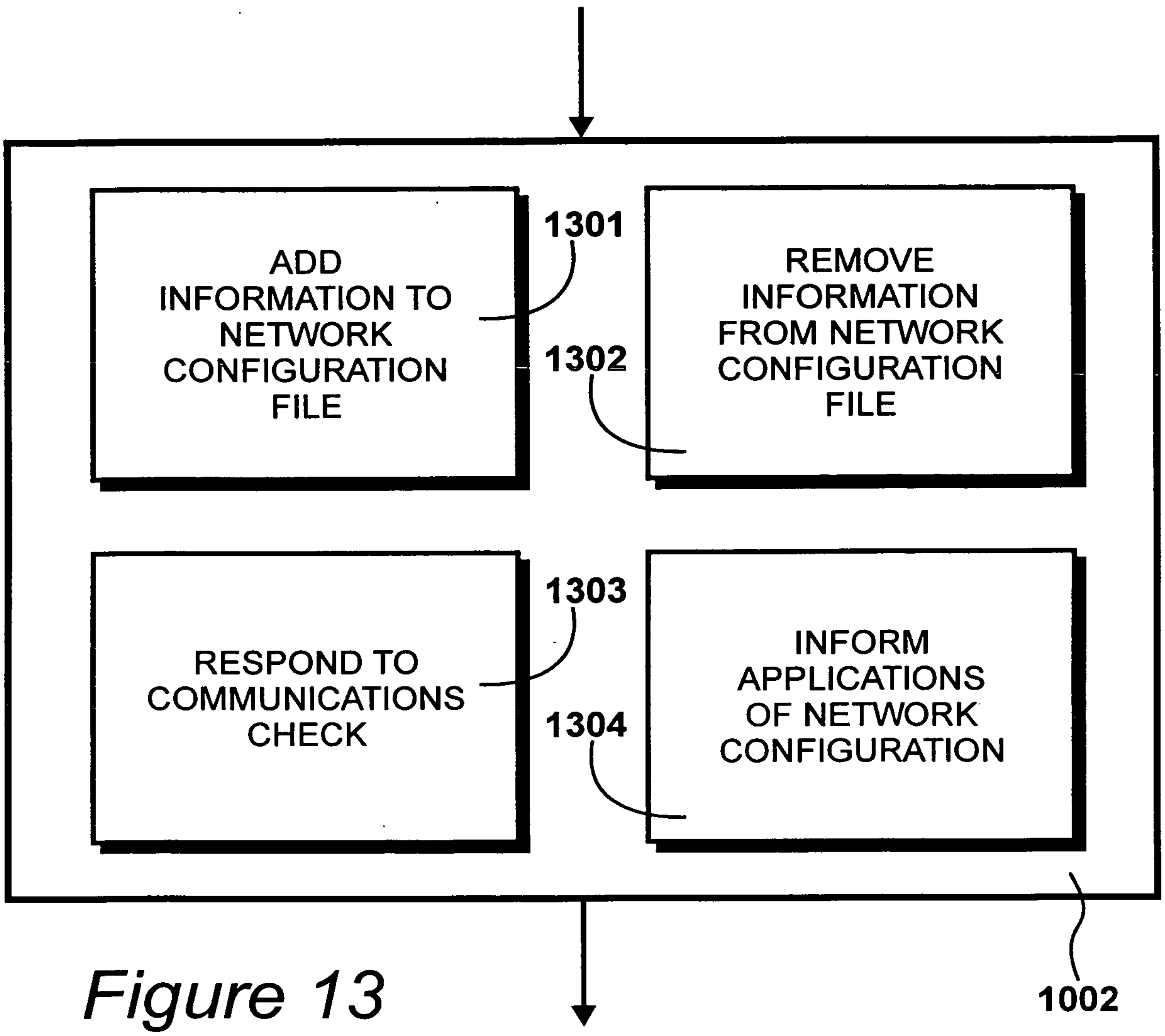

ADD INFORMATION TO NETWORK CONFIGURATION FILE
1301
REMOVE INFORMATION FROM NETWORK CONFIGURATION FILE
1302
RESPOND TO COMMUNICATIONS CHECK
1303
INFORM APPLICATIONS OF NETWORK CONFIGURATION
1304
1002

Figure 13

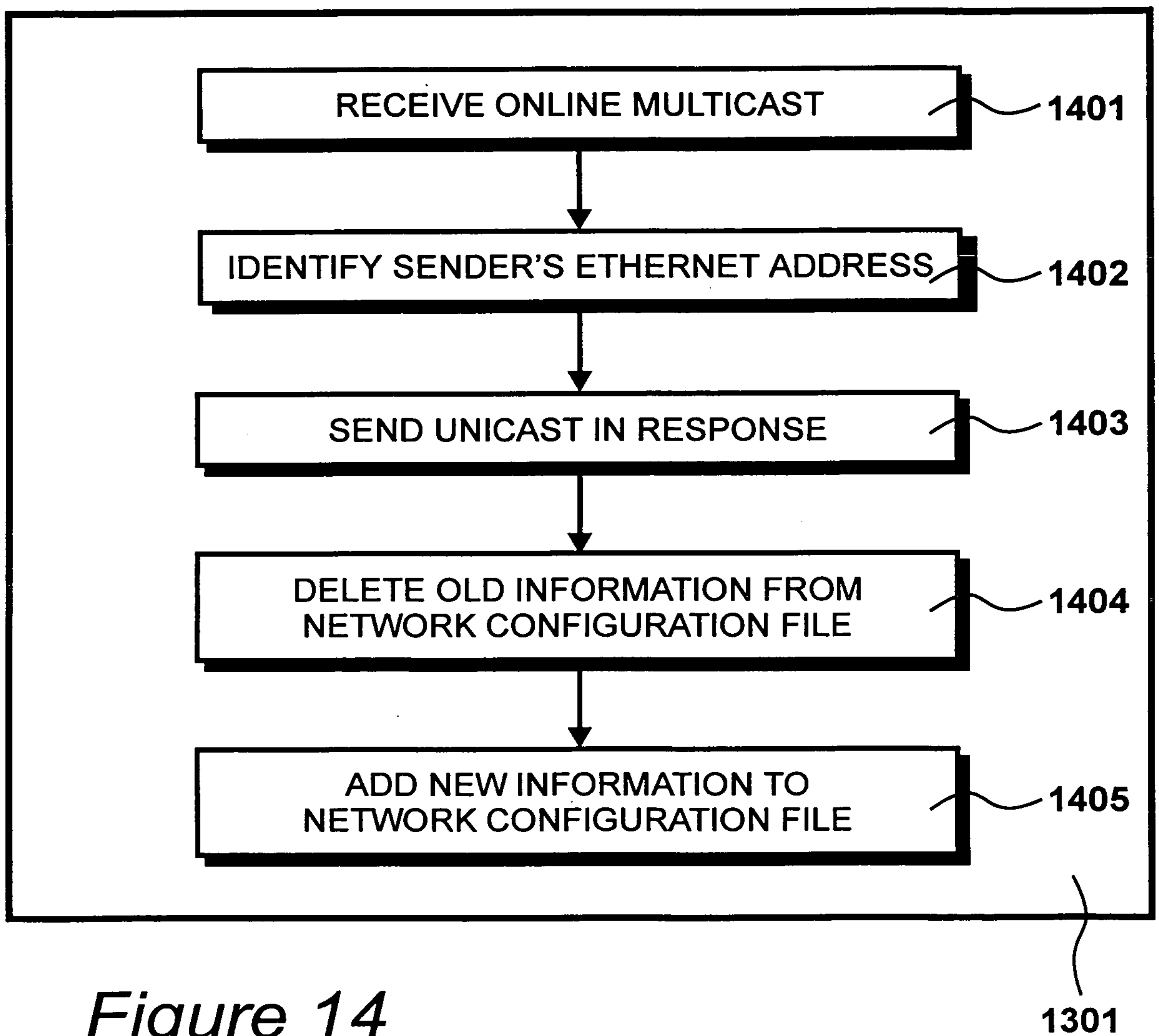

RECEIVE ONLINE MULTICAST
1401
IDENTIFY SENDER'S ETHERNET ADDRESS
1402
SEND UNICAST IN RESPONSE
1403
DELETE OLD INFORMATION FROM NETWORK CONFIGURATION FILE
1404
ADD NEW INFORMATION TO NETWORK CONFIGURATION FILE
1405
1301

Figure 14

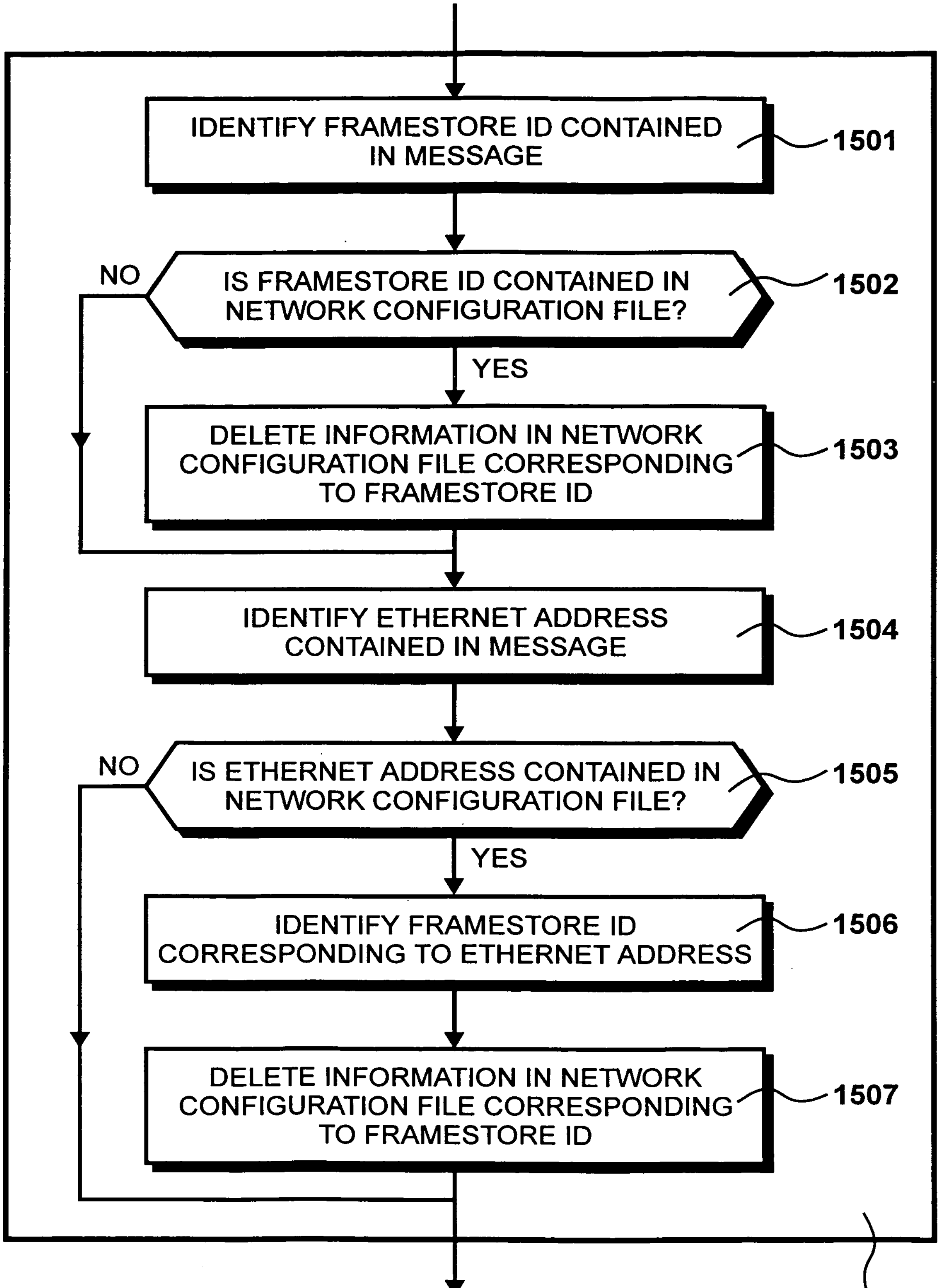

IDENTIFY FRAMESTORE ID CONTAINED IN MESSAGE
1501
IS FRAMESTORE ID CONTAINED IN NETWORK CONFIGURATION FILE?
1502
NO
YES
DELETE INFORMATION IN NETWORK CONFIGURATION FILE CORRESPONDING TO FRAMESTORE ID
1503
IDENTIFY ETHERNET ADDRESS CONTAINED IN MESSAGE
1504
IS ETHERNET ADDRESS CONTAINED IN NETWORK CONFIGURATION FILE?
1505
NO
YES
IDENTIFY FRAMESTORE ID CORRESPONDING TO ETHERNET ADDRESS
1506
DELETE INFORMATION IN NETWORK CONFIGURATION FILE CORRESPONDING TO FRAMESTORE ID
1507
1404

Figure 15

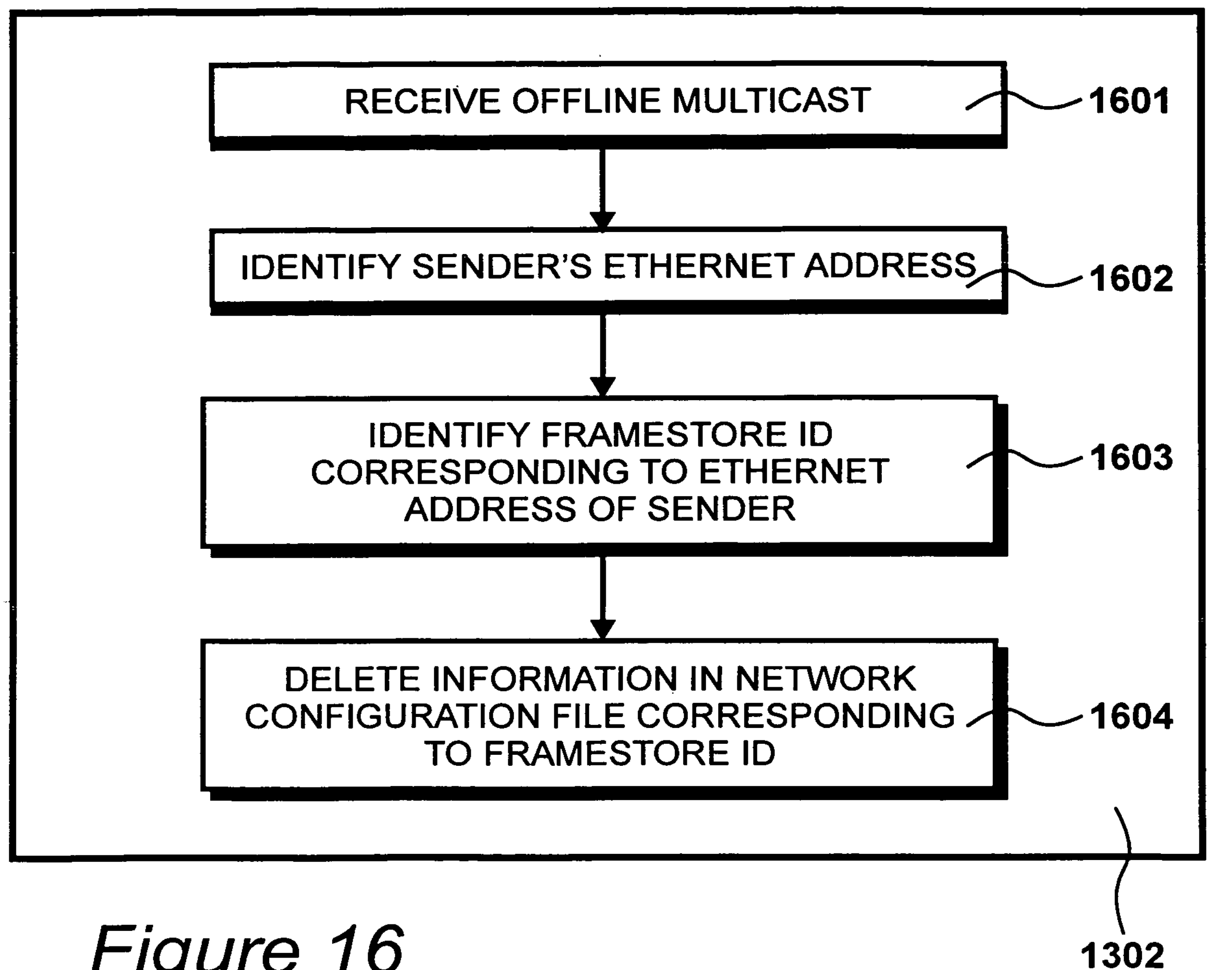

RECEIVE OFFLINE MULTICAST
1601
IDENTIFY SENDER'S ETHERNET ADDRESS
1602
IDENTIFY FRAMESTORE ID CORRESPONDING TO ETHERNET ADDRESS OF SENDER
1603
DELETE INFORMATION IN NETWORK CONFIGURATION FILE CORRESPONDING TO FRAMESTORE ID
1604
1302

Figure 16

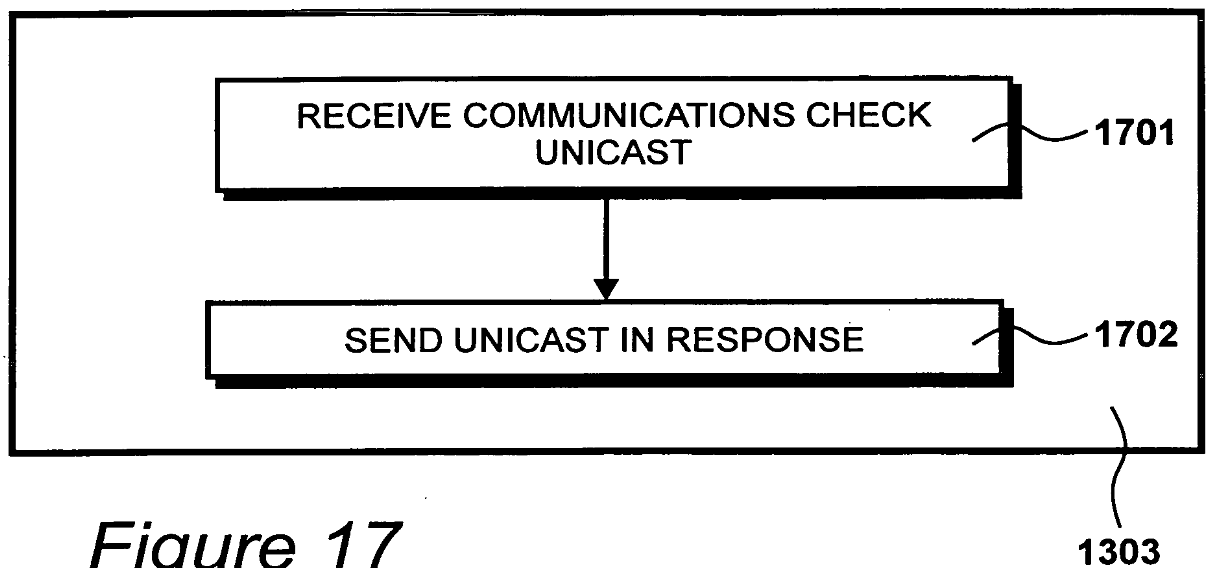
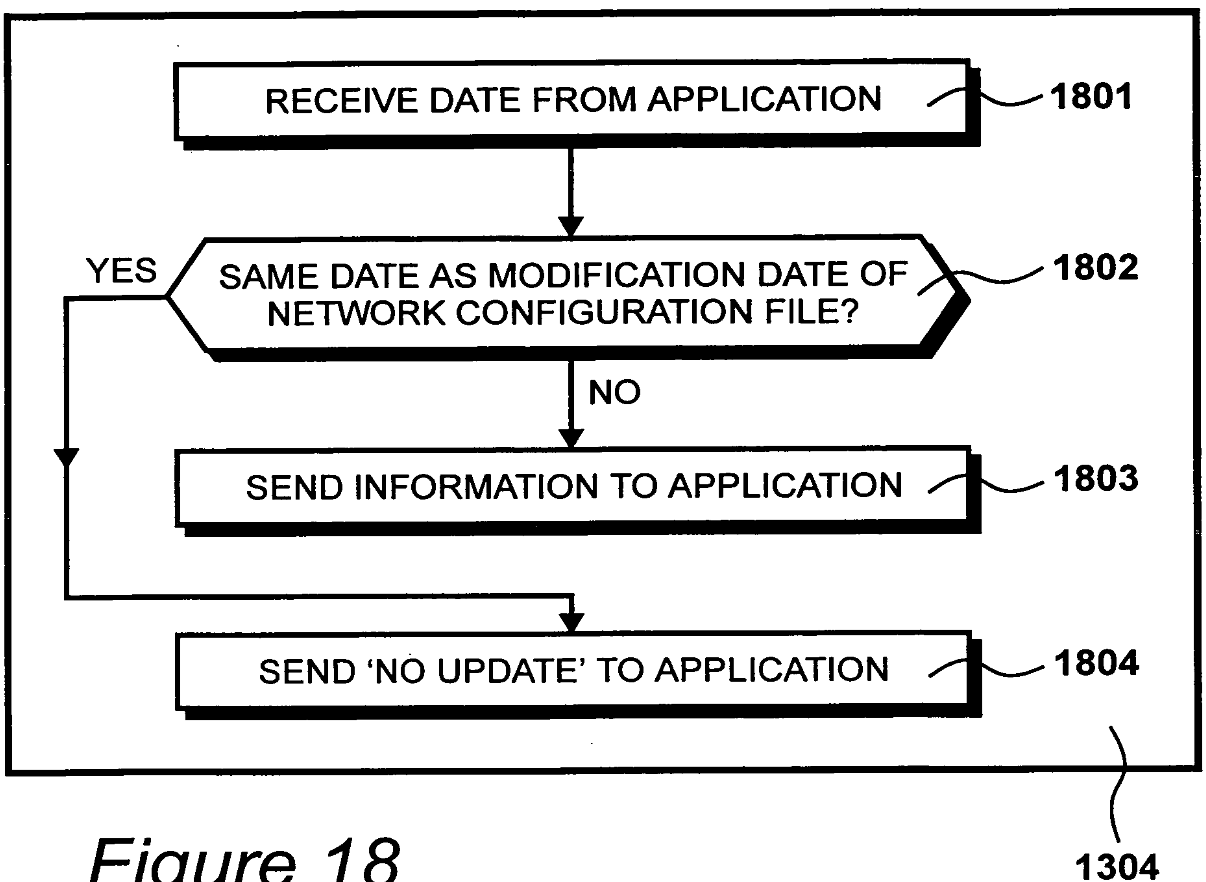

RECEIVE COMMUNICATIONS CHECK UNICAST
1701
SEND UNICAST IN RESPONSE
1702
1303

Figure 17



RECEIVE DATE FROM APPLICATION
1801
YES
SAME DATE AS MODIFICATION DATE OF NETWORK CONFIGURATION FILE?
1802
NO
SEND INFORMATION TO APPLICATION
1803
SEND 'NO UPDATE' TO APPLICATION
1804
1304

Figure 18

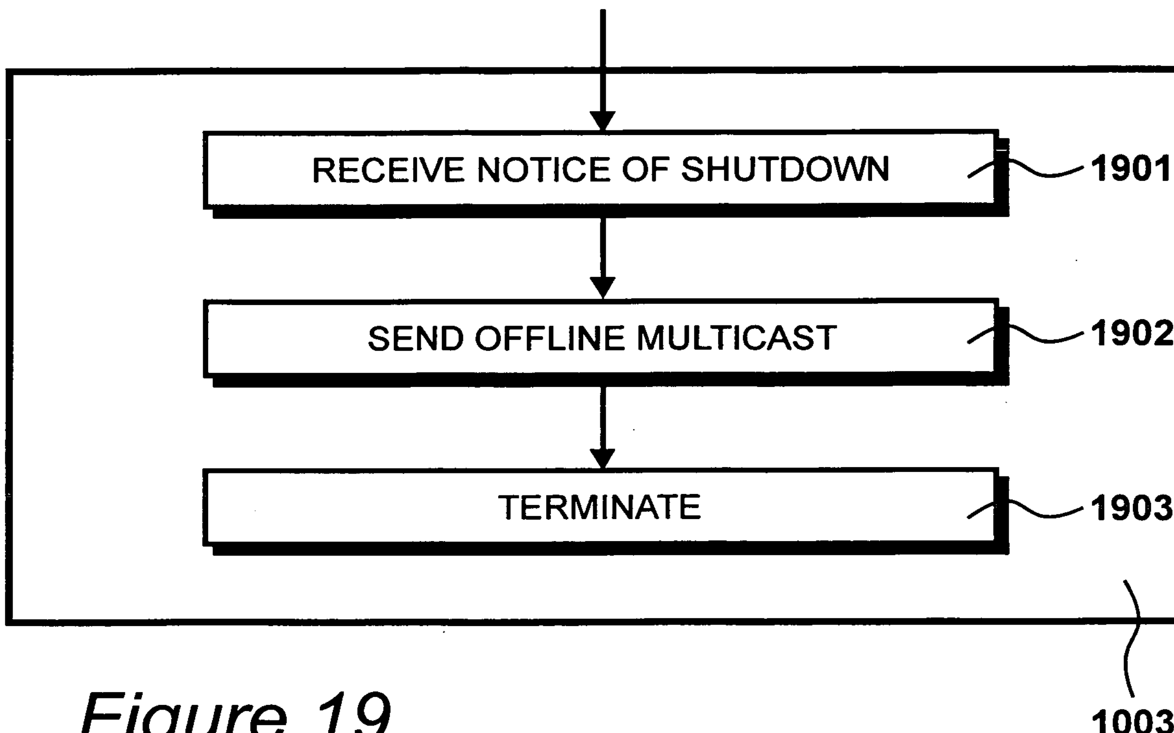

RECEIVE NOTICE OF SHUTDOWN
1901
SEND OFFLINE MULTICAST
1902
TERMINATE
1903
1003

Figure 19

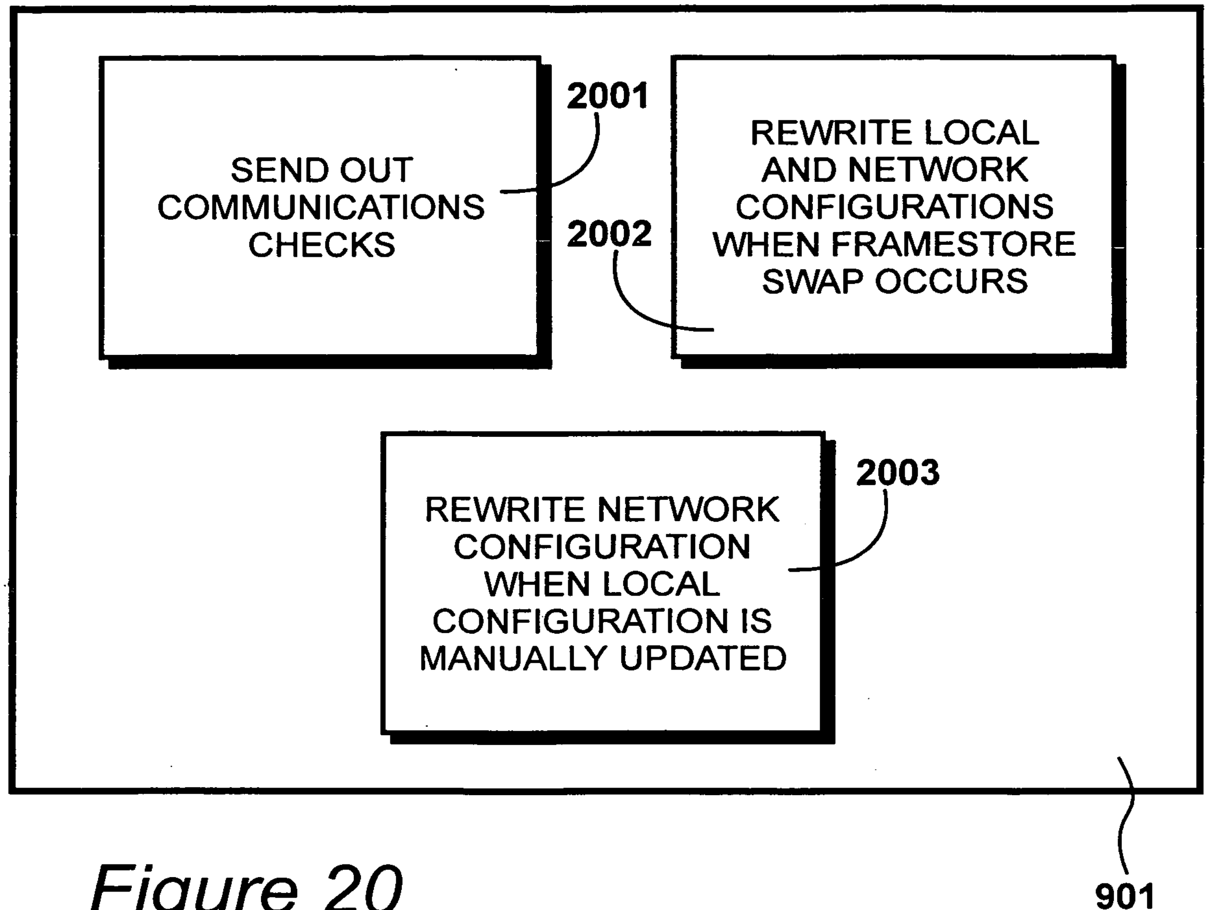

SEND OUT COMMUNICATIONS CHECKS
2001
REWRITE LOCAL AND NETWORK CONFIGURATIONS WHEN FRAMESTORE SWAP OCCURS
2002
REWRITE NETWORK CONFIGURATION WHEN LOCAL CONFIGURATION IS MANUALLY UPDATED
2003
901

Figure 20

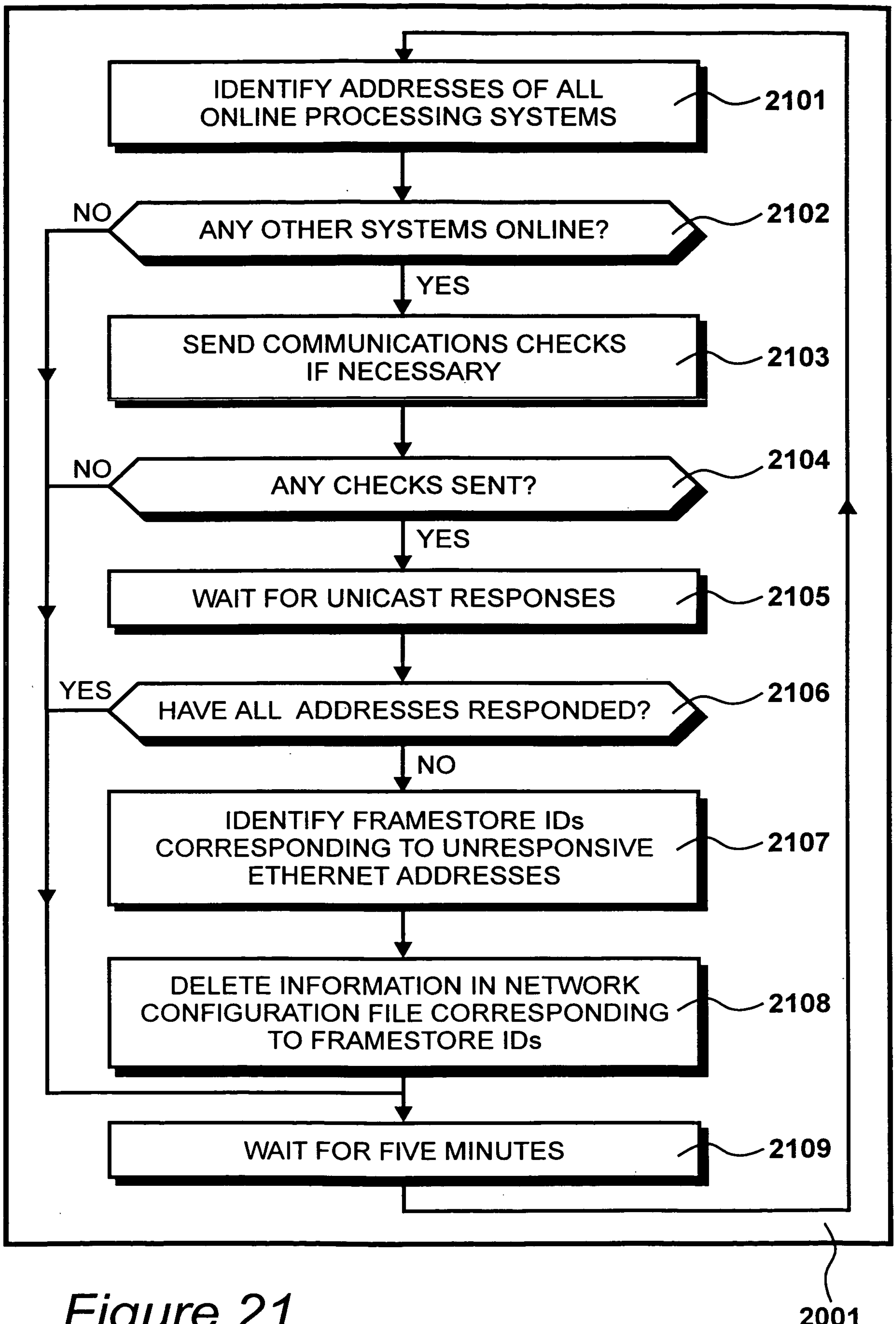

IDENTIFY ADDRESSES OF ALL ONLINE PROCESSING SYSTEMS
2101
ANY OTHER SYSTEMS ONLINE?
2102
NO
YES
SEND COMMUNICATIONS CHECKS IF NECESSARY
2103
ANY CHECKS SENT?
2104
NO
YES
WAIT FOR UNICAST RESPONSES
2105
HAVE ALL ADDRESSES RESPONDED?
2106
YES
NO
IDENTIFY FRAMESTORE IDs CORRESPONDING TO UNRESPONSIVE ETHERNET ADDRESSES
2107
DELETE INFORMATION IN NETWORK CONFIGURATION FILE CORRESPONDING TO FRAMESTORE IDs
2108
WAIT FOR FIVE MINUTES
2109
2001

Figure 21

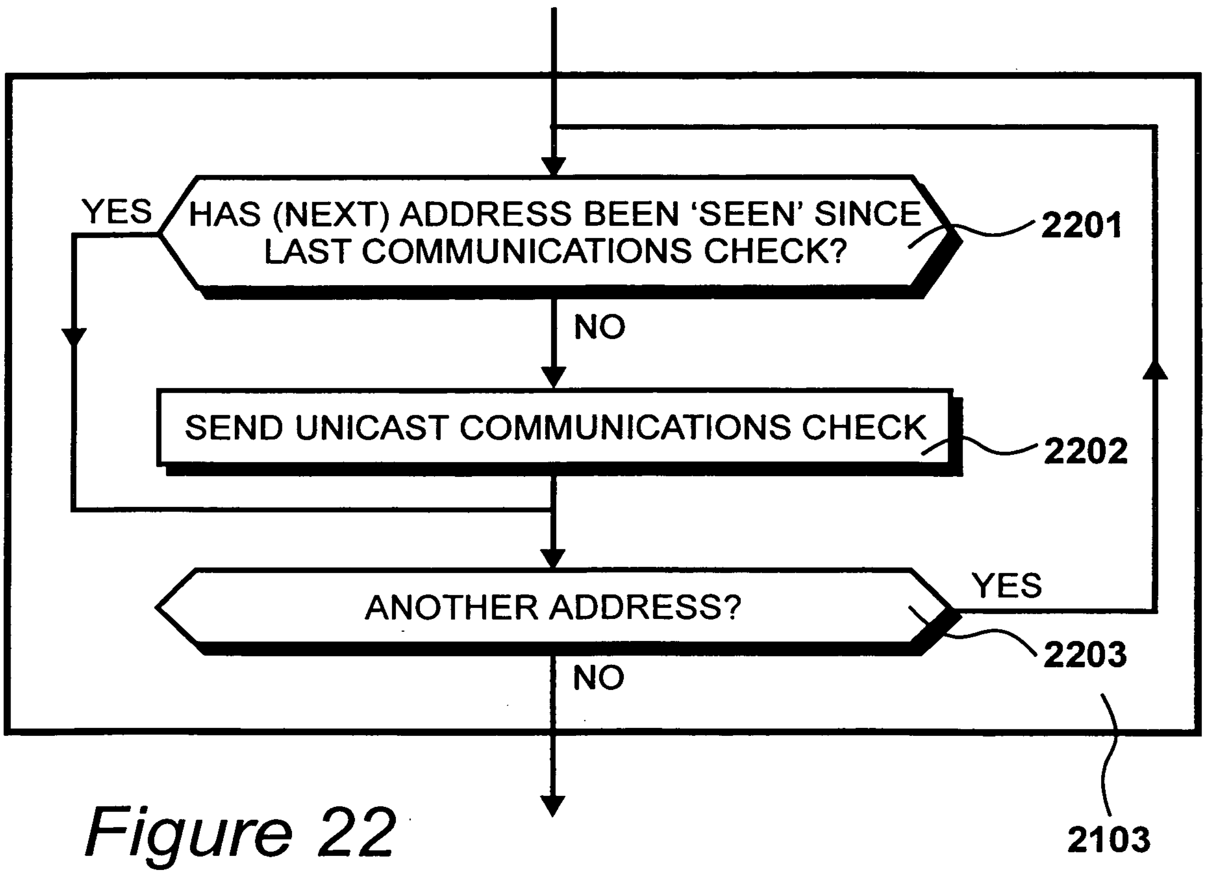

HAS (NEXT) ADDRESS BEEN 'SEEN' SINCE LAST COMMUNICATIONS CHECK?
YES
NO
2201
SEND UNICAST COMMUNICATIONS CHECK
2202
ANOTHER ADDRESS?
YES
NO
2203
2103

Figure 22

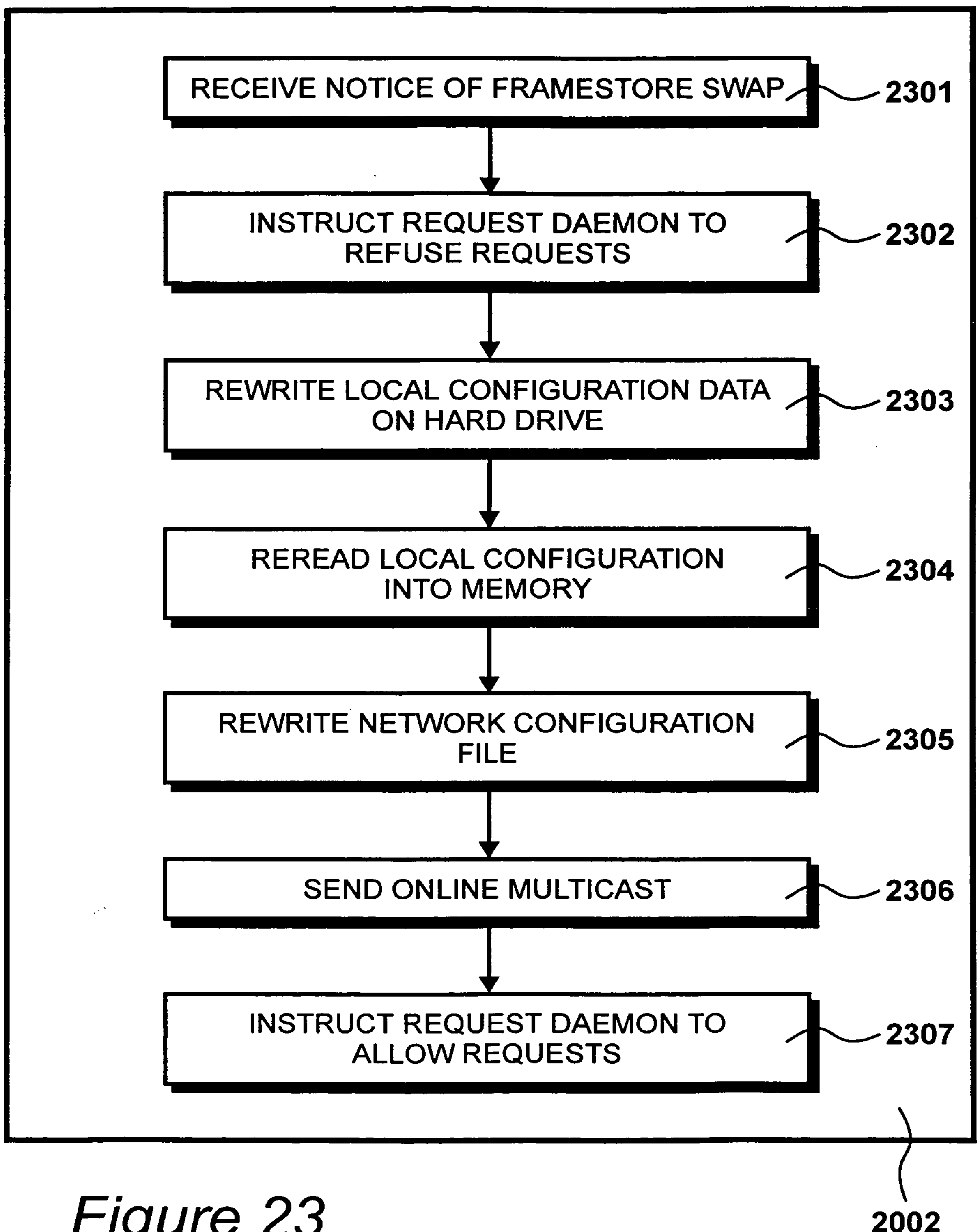

RECEIVE NOTICE OF FRAMESTORE SWAP
2301
INSTRUCT REQUEST DAEMON TO REFUSE REQUESTS
2302
REWRITE LOCAL CONFIGURATION DATA ON HARD DRIVE
2303
REREAD LOCAL CONFIGURATION INTO MEMORY
2304
REWRITE NETWORK CONFIGURATION FILE
2305
SEND ONLINE MULTICAST
2306
INSTRUCT REQUEST DAEMON TO ALLOW REQUESTS
2307
2002

Figure 23

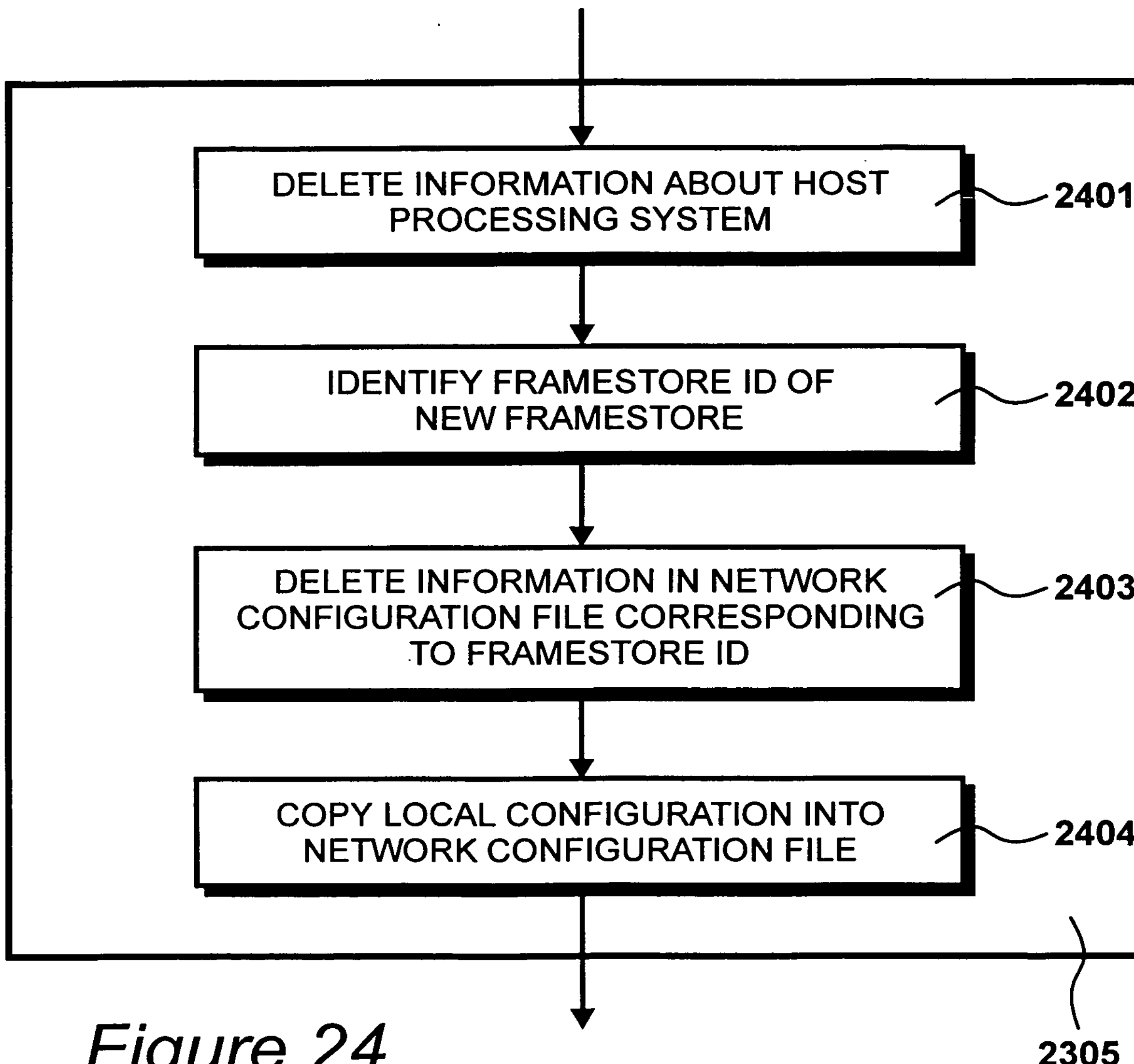

DELETE INFORMATION ABOUT HOST PROCESSING SYSTEM
2401
IDENTIFY FRAMESTORE ID OF NEW FRAMESTORE
2402
DELETE INFORMATION IN NETWORK CONFIGURATION FILE CORRESPONDING TO FRAMESTORE ID
2403
COPY LOCAL CONFIGURATION INTO NETWORK CONFIGURATION FILE
2404
2305

Figure 24

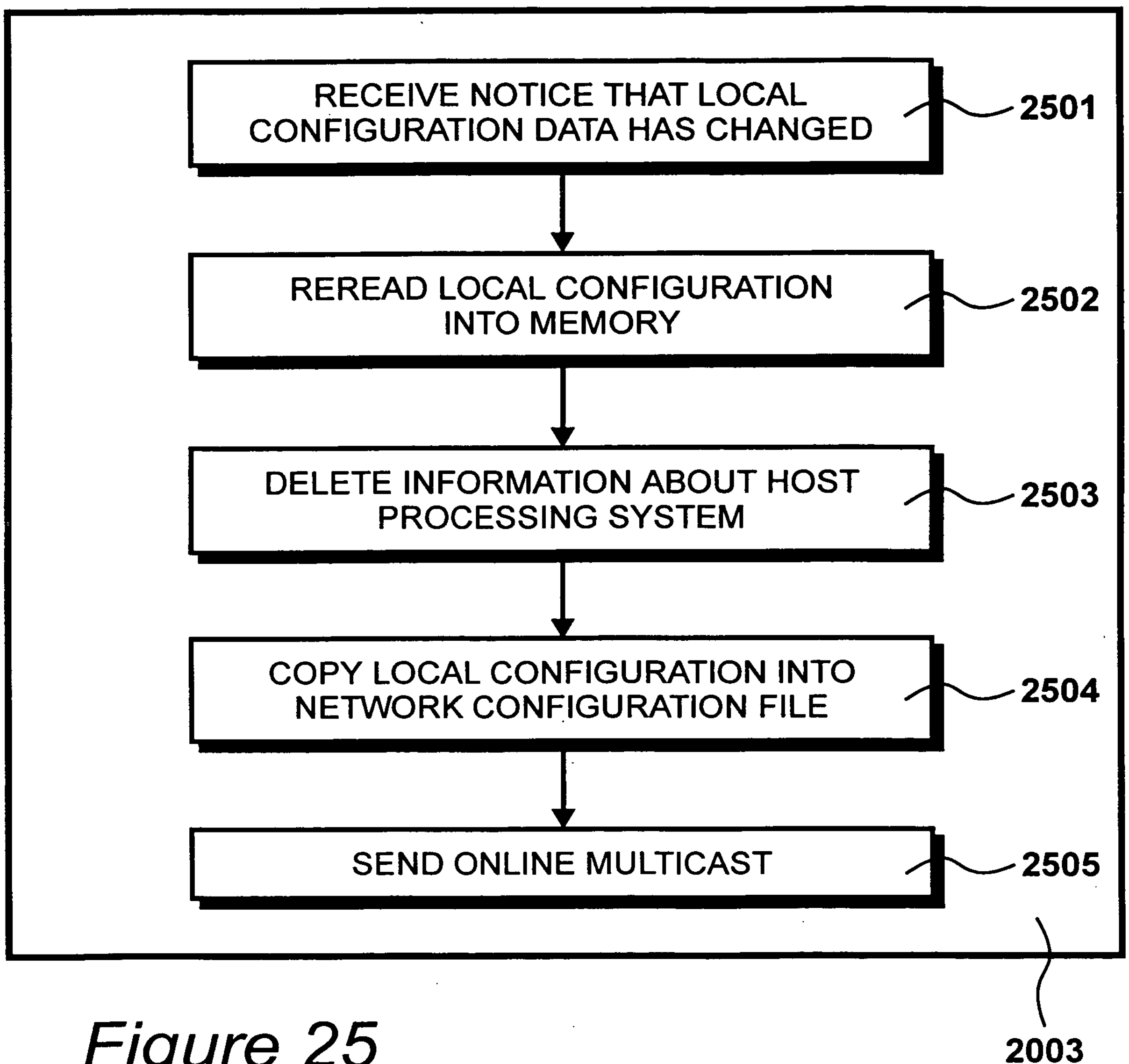

RECEIVE NOTICE THAT LOCAL CONFIGURATION DATA HAS CHANGED
2501
REREAD LOCAL CONFIGURATION INTO MEMORY
2502
DELETE INFORMATION ABOUT HOST PROCESSING SYSTEM
2503
COPY LOCAL CONFIGURATION INTO NETWORK CONFIGURATION FILE
2504
SEND ONLINE MULTICAST
2505
2003

Figure 25